भाकृअनुप
ICAR

ICAR-IIWM

वार्षिक प्रतिवेदन
ANNUAL REPORT 2017-18

ICAR-IIWM

भाकृअनुप – भारतीय जल प्रबंधन संस्थान
भुवनेश्वर, ओड़िशा – ७५१ ०२३

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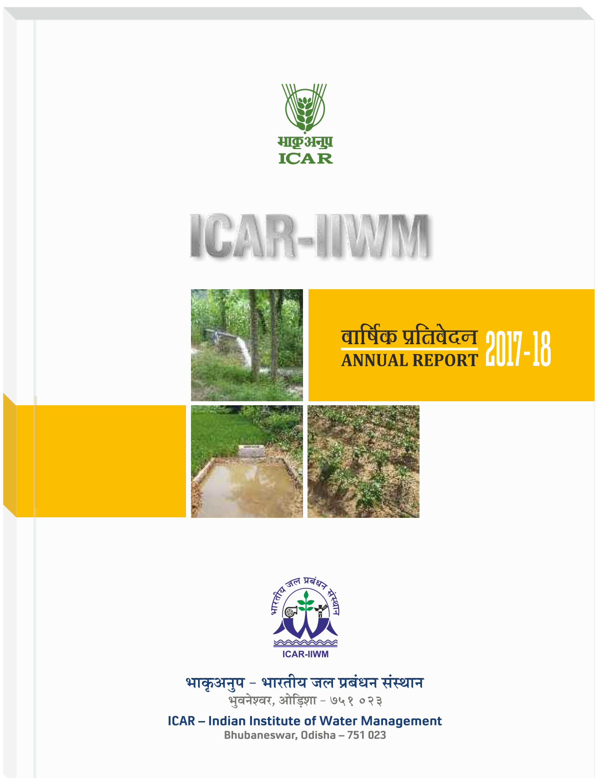

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PREFACE

Preface

Hon'ble Prime Minister of the country has urged for doubling farmers' income by 2022. To achieve the target, agricultural water management would play a key role in enhancing agricultural productivity, and farmer's income through multi-enterprise based farming, value addition of farm produce and better marketing. Despite spectacular achievements in agricultural production, critical challenges exist with respect to land and water resources in the country. There has been a sharp decline in average size of land holdings, mounting pressure on land and water, spatio-temporal variability of rainfall, declining per capita availability of water, fall in decadal growth rate of net irrigated area, declining public investments in major and medium irrigation projects, sub-optimal utilization of irrigation potential, low irrigation efficiency, groundwater depletion and regional imbalances in groundwater development, insufficient water storage structures for rainwater harvesting and auxiliary pond or tanks for storage of excess canal water delivered, low coverage of area under micro-irrigation practices, controlling waterlogging and soil salinity, combating water pollution and use of wastewater for irrigation etc. With these background and challenges, this premier institute has been striving continuously towards research and development on agricultural water management for different agro-ecological sub-regions in the country, capacity building of associated personnel and farmers, and transfer of technologies. Significant achievements have been made on the lines of set targets through different schemes and projects undertaken during the year 2017-18, and I feel extremely happy to bring out the detailed presentation of Institute's progress in the form of this Annual Report of the Institute for the year 2017-18.

Significant research achievements for the year 2017-18 have been included in this annual report under four approved programs of the Institute i.e., rainwater management (including waterlogged area management), canal water management, groundwater management and on-farm technology dissemination (including wastewater management, water policy & governance). Our scientists are actively involved in development of irrigation plans; safe drainage of excess water, computing virtual water and water trade potential for agro-based products; development of runoff water recycling, and land modification/shaping technique for enhancing productivity; water and nutrient self-reliant farming system for rainfed areas; climate resilient agriculture, groundwater management for enhancing adaptive capacity to climate change, design of groundwater recharge structures for hard rock areas, assessment of groundwater contamination and its management, options for enhancing irrigation efficiency and development of integrated farming systems in canal commands, water saving techniques in rice and rice-fallow areas through pulse crops, standardizing micro-irrigation technologies, water budgeting for aquaculture including prawn farming for enhancing water productivity. For management of waterlogged areas, drainage planning of eastern coast delta and optimal cropping pattern; index-based flood insurance and post-flood disaster management has been suggested. Studies are being carried out for bioremediation of polluted water, impact assessment of industrial wastewater, development and evaluation of mini-pan evaporimeter for irrigation scheduling, intensive horticultural system for improving farm income from degraded lands, social and sustainability implications of water management interventions. A substantial work has been done for livelihood improvement of tribal farmers through water management intervention and revival of village ponds through scientific intervention. Our institute has also initiated development of web-based expert system on agricultural water management.

Under the *Pradhan Mantri Krishi Sinchayee Yojana* (PMKSY) of the Government of India, Institute has played a major role in capacity building for project implementing agencies of Government of Odisha and for farmers of Bihar. In addition, different agricultural water management related issues at the regional level are being addressed by different centres under the AICRP on Irrigation Water Management. Through ICAR-Agri-Consortia Research Platform on Water project, institute has successfully installed rubber dams in different agro-ecological regions of India, initiated improvement strategies for higher water productivity in canal commands, drip-irrigation in horticultural crops, eco-friendly wastewater treatment, multiple use of water in aquaculture production systems, addressing issues related to water governance and policy. With the aim of dissemination of technology and working with farmers, our scientists are involved with thirty adopted villages across seven blocks in Odisha under *Mera Gaon Mera Gaurav* (MGMG) programme; conducted training programs for Government officials, farmers and students on various aspects of water management; conducted *Krishi Unnati Mela*, and showcased technologies developed by the institute through demonstration, *Kisan Mela, Kisan Gosthi*, exhibitions etc. Scientists of the Institute have published a good number of research papers in reputed and peer-reviewed journals, books/ bulletins/ training manuals and popular articles during the year 2017-18. ICAR-IIWM has been recognized as ISO 9001:2015 certified research institute in the field of Agricultural Water Management. Our Scientists have received *Utkal Diwas Samman*-2017, Fellow Award by prestigious national Societies and Academies in the country, young scientists award, *Krishi Vigyan Gaurav-2017, Swachhata Puraskar,* along with many others honours and recognitions.

I acknowledge sincerely the valuable guidance, suggestion and support of Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR; Dr. K. Alagusundaram, Deputy Director General (Agricultural Engineering & NRM), ICAR; Dr. S.K. Chaudhari, Assistant Director General (S&WM), NRM, ICAR, New Delhi and other concerned officials of the Council. I express my sincere thanks to the esteemed Chairman and members of QRT, RAC and IMC for their valuable guidance, inputs and involved support. I thank all members of IRC, Chairman, program leaders and members of different institute committee, staff of administration and finance section of the Institute for help, co-operation and smooth functioning of the Institute. The publication committee deserves applaud and appreciation for their untiring efforts in compilation and editing the Annual Report, and its timely publication. I hope that our Annual Report will be immensely useful for stake holders i.e. policy makers, researchers, development functionaries and the farmers.

(S.K. Ambast)
Director, ICAR-IIWM

June 30, 2018
Bhubaneswar

कार्यकारी सारांश

वर्षा आधारित क्षेत्रों के लिये जल एवं पौषक तत्व आत्मनिर्भर खेती पद्धति : आत्मनिर्भर खेती पद्धति (1.5 हेक्टेयर क्षेत्र से ₹ 131510) से पारंपरिक धान-परती और धान- यूटीरा (उड़द) फसल पद्धतियों की तुलना में शुद्ध लाभ क्रमश: 3.4 और 3.0 गुणा अधिक प्राप्त हुआ। इस फसल पद्धति से धान-परती और धान-यूटीरा (उड़द) फसल पद्धतियों की तुलना में जल उत्पादकता (₹ 13.2/घन मीटर) क्रमश: 4.5 और 4.1 गुणा अधिक प्राप्त हुई।

पूर्वी तटीय डेल्टा की जल निकास योजना : पूर्वी तट डेल्टा (भार्गवी-दया दोआब) की जल निकास योजना को भू-सूचना विज्ञान उपकरण का उपयोग करके तैयार किया गया। जल निकास के घनत्व को कम से कम 0.50 तक बढ़ाया जाना चाहिए, जिससे दोआब में 330 किलोमीटर लंबाई की अतिरिक्त नाली को बनाया जा सके। मौजूदा नालियों और धाराओं से तलछट को हटाना चाहिए। लगभग 3.4% क्षेत्र जिसमें अधिकांश जल स्रोत या निकाय पाये गये हैं वो या तो खरपतवार की समस्या से ग्रस्त है या तलछट की समस्या से प्रभावित हैं इसलिये, अच्छी गुणवत्ता वाले जल को संचित करने और सिंचाई प्रदान करने के लिये इनको पुन:निर्मित करने की आवश्यकता है। इन क्षेत्रों के लिये किसानों को उचित फसल योजना भी सुझाई गई है।

पेसिफीक सफेद झींगा पालन में जल का कम उपयोग : पेसिफीक सफेद झींगा (लिटोपिनियस वानैमी) के पालन में, 5 लाख झींगा बीज/हेक्टेयर के इष्टतम स्टॉकिंग घनत्व के साथ सर्वोत्तम प्रबंधन विधि द्वारा वृद्धि एवं उत्पादन में बिना किसी कमी के कुल जल उपयोग को 33,300 घन मीटर तक और जल के आदान-प्रदान को 6,300 घनमीटर/हे तक घटाया जा सकता है। इस स्टॉकिंग घनत्व के साथ 120 दिन में झींगा की उत्पादकता का स्तर 10.4 टन/हे तक बढ़ा। इसके अलावा, इस तकनीक का उपयोग करके ₹ 78.3/घन मीटर जल की शुद्ध आय प्राप्त की जा सकती है तथा एक किलोग्राम झींगा का उत्पादन करने के लिये 1.84 घनमीटर जल की आवश्यकता हुई।

सूक्ष्म सिंचाई का उपयोग करके दलहन उत्पादकता में वृद्धि : मूँग की दो महत्वपूर्ण फसल विकास अवस्थाओं जैसे फूल आने एवं फली बनने पर स्प्रिंकलर विधि से सिंचाई के परिणामस्वरूप केवल एक सिंचाई और नियंत्रण उपचार की तुलना में अधिकतम जल उत्पादकता प्राप्त हुई। दो सिंचाइयों एवं यूरिया तथा राइजोबियम के माध्यम से 20 किलोग्राम/हे की दर से नाइट्रोजन के प्रयोग के कारण फसल की फली उपज में 0.46 से 0.94 टन/हेक्टेयर तक वृद्धि हुई तथा शुद्ध जल उत्पादकता ₹ 2.30 से ₹ 6.43/घनमीटर तक बढ़ी।

सिंचाई समय के निर्धारण हेतु मिनी-पैन वाष्पीकरण मीटर का विकास और मूल्यांकन : गैल्वेनाइज्ड आयरन (GI) शीट और पीवीसी (PVC) पाइप से 25 सेमी की ऊँचाई तथा तीन तरह के व्यास (10, 20 और 30 सेमी) वाले मिनी-पैन वाष्पीकरण मीटरों को बनाया गया। यूएसडब्ल्यूबी (USWB) ओपन पैन के वाष्पीकरण आँकड़ों के साथ पीवीसी और गैल्वेनाइज्ड आयरन से निर्मित मिनी पैन वाष्पीकरण मीटर के वाष्पीकरण आँकड़ों के स्कैटर प्लॉट (ग्राफ) से पता चला कि 30 सेमी व्यास वाले गैल्वेनाइज्ड आयरन से निर्मित मिनी पैन से दर्ज वाष्पीकरण में अन्य मिनी पैन की तुलना में प्राप्त वाष्पीकरण के साथ अधिकतम संबंध (R^2= 0.95) प्राप्त हुआ।

तटीय जलाक्रांत क्षेत्रों में कृषि आय बढ़ाने हेतु भूमि रूपान्तरण के विकल्प : इस परियोजना की शुरूआत इसी वर्ष की गई है। सुनियोजित भूमि रूपान्तरण की योजना बनाने के लिये चयनित स्थलों का प्रारम्भिक सामाजिक-आर्थिक सर्वेक्षण किया गया और यहाँ पर जल स्तर का भी मूल्यांकन किया गया।

धान एवं गेहूँ की फसलों के वैश्विक उपज अंतर पर अध्ययन : इस अनुसंधान के अंतर्गत एपसीम (APSIM) मॉडल का उपयोग करके भारत के विभिन्न जलवायु बफर क्षेत्रों की संभावित उपज, वास्तविक उपज और उपज में अंतर की प्रवृत्ति का अनुमान लगाया गया। पटियाला (पंजाब) एवं पटना (बिहार) में धान की उपज में

अंतर क्रमशः 52.6 और 83.4% तक प्राप्त हुआ, जबकि पंजाब के पटियाला और हिमाचल प्रदेश के पलामपुर में गेहूँ की उपज में अंतर क्रमशः 22.5 एवं 68.2% था।

सूचकांक आधारित बाढ़ बीमा (IBFI) और प्राकृतिक आपदा के बाद प्रबंधन : बिहार राज्य के मुजफ्फरपुर जिले में खरीफ मौसम के दौरान कृषि फसलों में बाढ़ से होने वाली क्षति का आकलन किया गया और बाढ़ ग्रसित क्षेत्रों में बाढ़ प्रबंधन योजना तैयार की गई। इस बाढ़ ग्रसित पारिस्थितिकी तंत्र हेतु फसल प्रबंधन योजना जैसे कि धान की डबल रोपण विधि (खरुहन); गहरी जलाक्रांत प्रतिरोधी किस्म जैसे 'वर्षाधान'; 60 दिन के धान की पौध का रोपण और पानी सिंघाड़ा आधारित कृषि पद्धति को बेहतर तथा अनुकूलित पाये जाने का सुझाव दिया गया।

नहरी कमांड के अंतर्गत सिंचाई की दक्षता में सुधार : ओडिशा राज्य के सुंदरगढ़ जिले में घुरलीजोर माइनर सिंचाई कमांड के अंतर्गत नहर से जुड़े जलाशयों और कुंआ आधारित स्प्रिंकलर सिंचाई के माध्यम से निर्मित उपलब्ध जल संसाधनों को फसल उत्पादन के लिये उपयोग में लिया गया। इन निर्मित सिंचाई के बुनियादी ढाँचों से वर्षा जल का उपयोग करके और जलाशय से पूरक सिंचाई का प्रयोग करके धान की उपज 3.6 टन/हे तथा जल उत्पादकता 0.29 किलोग्राम/घनमीटर तक प्राप्त हुई। चेक बेसिन सिंचाई विधि की तुलना में स्प्रिंकलर सिंचाई प्रणाली को अपनाने से मूँगफली की फसल में 40% कम सिंचाई जल के उपयोग के साथ-साथ 12.5% अधिक उत्पादन प्राप्त हुआ और जल उत्पादकता में 87% की बढ़ोतरी हुई। इस तकनीक के कारण, सिंचाई तीव्रता में 164% तक वृद्धि हुई और लक्षित क्षेत्र में औसत वार्षिक शुद्ध आय ₹ 17800/हे से ₹178000 हे तक बढ़ी।

वाटर फूटप्रिंट्स (आभासी जल) का आकलन : पंजाब, ओडिशा और तमिलनाडु राज्यों में आरसीपी 8.5 परिदृश्य के तहत क्रमश: वर्ष 2050, 2070 और 2090 में धान की फसल के वाटर फूटप्रिंट्स की 2.5, 4.3-7.1 और 9.4-11.3% तक बढ़ने की संभावना पायी गई है। कृषि में वाटर फूटप्रिंट्स को कम करने के लिये सूक्ष्म सिंचाई एक बहुत ही अच्छा विकल्प है। ओडिशा राज्य के ढेंकानाल जिले में कठोर चट्टानी क्षेत्रों में, सतही सिंचाई प्रणाली (1.0 IW/CPE) की तुलना में कुंआ आधारित ड्रिप सिंचाई प्रणाली के माध्यम से फूलगोभी, आलू और मिर्च की फसलों में क्रमशः 51.5, 63.8 और 63.9% तक वाटर फूटप्रिंट्स कम पाया गया।

धान की खेती की विधियों तथा जल संरक्षण सिंचाई विधि का मूल्यांकन : खेत पर परीक्षणों से पता चला कि धान की फसल का प्रदर्शन खरीफ के साथ-साथ रबी (गर्मी) के मौसम के दौरान, सीधे बीज बुआई (DSR) विधि और पडलिंग स्थिति के तहत रोपण विधि से प्राप्त परिणाम लगभग एक समान थे। रबी के दौरान, वैकल्पिक गीली और सुखी (AWD) विधि और खेत में जल के सूखने के 3 दिनों बाद सिंचाई (3-DAD) विधि की तुलना निरंतर बाढ़ (CF) सिंचाई विधि के साथ की गई। धान की उपज सभी सिंचाई प्रणालियों में सांख्यिकीय रूप से समान प्राप्त हुई। निरंतर बाढ़ सिंचाई विधि की तुलना में खेत में जल के सूखने के 3 दिनों बाद सिंचाई विधि एवं वैकल्पिक गीली और सुखी विधि में जल की बचत क्रमशः 22 और 28% तक हुई। नतीजतन, बाढ़ सिंचाई विधि की तुलना में जल उत्पादकता में क्रमश: 27 और 38% की बढ़ोतरी हुई। अतः इस क्षेत्र के लिए जल के सूखने के 3 दिनों बाद सिंचाई विधि एवं वैकल्पिक गीली और सुखी विधि को उपयुक्त पाया गया।

नहरी सिंचाई प्रणाली के प्रदर्शन का आकलन करने हेतु बेंचमार्किंग : महाराष्ट्र राज्य की प्रमुख और मध्यम सिंचाई परियोजनाओं के लिये वाटर ऑडिटींग आँकड़ों का विश्लेषण किया गया। कई संकेतक जैसे 15 अक्टूबर को जलाशयों में जल की उपलब्धता, 15 अक्टूबर को लाइव स्टोरेज एवं वास्तविक वाष्पीकरण का प्रतिशत, लक्षित व वास्तविक सिंचाई क्षमता का उपयोग, जल उपयोग पैटर्न, सिंचाई प्रणाली का प्रदर्शन, योजनाबद्ध और वास्तविक गैर सिंचाई उपयोगों के बीच अनुपात, 15 अक्टूबर को अनुपयोगी जल व लाइव स्टोरेज के बीच अनुपात, मुख्य नहरों की निर्वहन दक्षता, और वास्तविक फसल पद्धति आदि का उपयोग इस विश्लेषण के लिये किया गया।

धान और मूँगफली की फसल पर सुपर अवशोषक पॉलिमर (SAP) का प्रभाव : फसल की वृद्धि एवं मूँगफली और धान की उपज पर सुपर अवशोषक पॉलिमर की विभिन्न मात्रा का मूल्यांकन करने के लिये खेत में एक प्रयोग किया गया। इस प्रयोग के परिणाम से यह प्राप्त हुआ कि मृदा के गुणों, फसल वृद्धि और पादप कार्यिकी प्रदर्शन पर सुपर अवशोषक पॉलिमर के विभिन्न स्तरों (0, 25, 50, 75 और 100 किलोग्राम/ हे) ने महत्वहीन प्रभाव दिखाया। लेकिन मूँगफली और धान की फसलों में सुपर अवशोषक पॉलिमर के विभिन्न स्तरों के बीच जल उत्पादकता क्रमशः11% और 4% तक पायी गई।

निकरा (NICRA) परियोजना की उपलब्धियाँ : धान की फसल में सकल प्राथमिक उत्पादकता (GPP), पारिस्थितिकी तंत्र श्वसन, शुद्ध पारिस्थितिकी तंत्र विनिमय (NEE) में मौसमी व दैनिक भिन्नता को एडी कोवेरियंस तकनीक का उपयोग करके निर्धारित किया गया। भिंडी एवं चंवला की फसलों पर फर्टिगेसन शिड्युलिंग प्रयोग को जारी रखा गया। भिंडी एवं चंवला की फसलों को सतह सिंचाई विधि + 100% सुझाई गई उर्वरकों की मात्रा की तुलना में जब ड्रिप सिंचाई प्रणाली +100% सुझाई गई उर्वरकों की मात्रा के तहत उगाया गया तो उत्पादकता में क्रमशः 53.6 और 68.9% की वृद्धि प्राप्त हुई। वर्षा जल संचय एवं तटबंध आधारित कृषि वानिकी से 3.0 के लाभ:लागत अनुपात के साथ ₹ 71811-98032/हे/वर्ष का लाभ प्राप्त हुआ, जिससे जलाक्रांत और बाढ़ ग्रसित क्षेत्रों को कम करने में मदद प्राप्त हुई। ब्राह्मणी नदी बेसिन में बदलते हुए जलवायु परिदृश्य के तहत भूजल की जाँच के माध्यम से संयोजी जल उपयोग रणनीति भी विकसित की गई।

सिंचाई की नहरी कमांड के तहत आर्थिक जल उत्पादकता में वृद्धि : अंतराष्ट्रीय जल प्रबंधन संस्थान (IWMI), कोलंबो, भाकृअनुप – भारतीय जल प्रबंधन संस्थान, भुवनेश्वर और सिंचाई जल प्रबंधन पर अखिल भारतीय समन्वित अनुसंधान परियोजना (AICRP-IWM), राहुरी (महाराष्ट्र) केंद्र के बीच एक सहयोगी अनुसंधान योजना को महाराष्ट्र राज्य के सीना मध्यम सिंचाई कमांड क्षेत्र में स्थायी रूप से आर्थिक जल उत्पादकता को बढ़ाने के लिये शुरु किया गया। महाराष्ट्र राज्य के बेंचमार्किंग आँकड़ों (2001-2011) के कुछ संकेतको ने बताया कि यह नहर प्रणाली अपनी क्षमता से अधिक प्रदर्शन दिखा रही है, जबकि अन्य संकेतक यह संकेत देते हैं कि यह 2009 के रेफरिंग

स्टेट मानक के अनुसार क्षमता से कम प्रदर्शन कर रही है। इस कमांड क्षेत्र में सिंचाई के बुनियादी ढाँचों का पता लगाने के लिये सिस्टमैटिक एसेट मैनेजमेंट (SAM) उपकरण का विकास प्रक्रिया में है।

क्षरित भूमि में गहन बागवानी प्रणाली : जल की उत्पादकता में सुधार और क्षरित भूमि से अधिक मुनाफा प्राप्त करने के लिये फूल नहीं आये हुये आम के बगीचे में इस प्रयोग को शुरू किया गया। जिसमें ड्रिप सिंचाई और धान के पुआल की पलवार के तहत पपीता और अनानास को अंत:सस्य पद्धति में उगाया गया। इन फसलों के वनस्पति विकास में कोई महत्वपूर्ण अंतर नहीं देखा गया। हालांकि, अनानास समतुल्य उपज आम के बगीचे में अंत:सस्य के रूप में उगाई गई अनानास की की फसल (पुआल पलवार के तहत) से अधिकतम (17.5 टन/हे) प्राप्त हुई और इसके साथ-साथ इस फसल पद्धति से अन्य फसल पद्धतियों की तुलना में जल उत्पादकता (21.1 किग्रा/हे-मिमी) में काफी वृद्धि हुई।

भूजल सिंचाई के सामाजिक, आर्थिक और पर्यावरणीय संबंध : दो गहन भूजल सिंचित जिलों जैसे पूर्वी और पश्चिमी गोदावरी जिलों का मूल्यांकन भूजल सिंचाई के सामाजिक, आर्थिक और पर्यावरणीय संबंधों को समझने के लिये किया गया। वायुमंडल की बढ़ती वाष्पीकरण माँगो को पूरा करने के लिये गर्मी के मौसम में धान की खेती हेतु भूजल ने एक महत्वपूर्ण भूमिका निभाई है। नतीजतन, पश्चिमी गोदावरी जिले में विशेष रूप से भूजल स्तर में तेजी से गिरावट आ गई है। यह प्रतीत होता है कि सरकार की नीतियाँ संसाधन हानि का एक उत्प्रेरक है, लेकिन इसके फलस्वरूप लाखों छोटे छोटे किसानों को सामाजिक लाभ भी हुआ है।

कठोर चट्टानी क्षेत्रों के लिये भूजल पुन:भरण संरचनाओं का डिजाइन : ओडिशा राज्य के दसपल्ला ब्लॉक में स्थित बारघरीयानाला वाटरशेड के कुल 637 हेक्टेयर क्षेत्र के लिये भूजल पुन:भरण संरचनाओं के निर्माण हेतु संभावित क्षेत्रों को चित्रित किया गया। श्रीरामपुर गाँव में वर्षा जल संचयन संरचना के तहत एक पुन:भरण कुएं (1.2 मीटर व्यास, 12 मीटर गहराई) का निर्माण किया गया। पुन:भरण संरचनाओं के प्रभाव से पता चला कि संरचनाओं के प्रभाव क्षेत्र (15 हे) में स्थित कुंओं में 0.7 मीटर तक भूजल स्तर में वृद्धि हुई। इस क्षेत्र के लिये भूजल पुन:भरण का आकलन 5.7 सेमी/वर्ष किया गया।

लोअर गोदावरी बेसिन में भूजल प्रदूषण का आकलन : लोअर गोदावरी बेसिन भारत में सबसे अधिक उपजाऊ और गहन रूप से खेती वाले क्षेत्र में से एक है। यूएसजीएस अर्थ एक्सप्लोरर और सीजीडब्ल्यूबी फिजियोग्राफी से प्राप्त एएसटीईआर (ASTER) और डीईएम (DEM) आँकड़ों का उपयोग करके भूजल की गहराई और गुणवत्ता का आकलन किया गया और भूजल के रासायनिक विश्लेषण ने बेसिन के उत्तरी भाग में नाइट्रेट प्रदूषण को दिखाया।

गन्ना की खेती में जलवायु परिवर्तन के तहत दक्ष भूजल प्रबंधन : यूपी के मुजफ्फरनगर जिले के रसूलपुर जत्तन गाँव के भूजल बजट से यह संकेत प्राप्त हुआ कि इस गाँव के लिये कुल भूजल भंडारण (-) 651063 घनमीटर था, जो कि भूजल स्तर में 1.36 मी. तक की वार्षिक गिरावट का अनुमान बताता है जबकि इस गाँव के पास में ही स्थित काकड़ा गाँव में सिर्फ 0.35 मी. तक भूजल में गिरावट दर्ज की गई। भविष्य के जलवायु आँकड़ों का विश्लेषण आरसीपी-4.5 परिदृश्य पर मार्कसिम ग्लोबल क्लाइमैटिक मॉडल (GCM) का उपयोग करके किया गया तथा विभिन्न परिदृश्यों तहत भविष्य की जल की माँग का आकलन दशकों के अंतराल पर किया गया। गन्ना की फसल के तहत क्षेत्र, बेहतर जल निर्वहन और प्रयोग विधि, पुन:भरण संरचनाओं की संख्या आदि पर विचार करके परिदृश्य तैयार किये गये। अंततः जल की उपलब्धता की तुलना जल की माँग से की गई और विभिन्न परिदृश्यों के लिये भूजल स्तर की भविष्यवाणी की गई।

तिलहन फसलों पर औद्योगिक अपशिष्ट जल का प्रभाव : ओडिशा राज्य के अंगुल औद्योगिक क्षेत्र की सतही जल गुणवत्ता के आकलन से पता चला कि मानसून के मौसम के दौरान उद्योगों के अधिकांश प्रदूषकों को छोड़ा जाता है जो कि सिंचाई के लिये अनुपयुक्त है। एक पोट एक्सपरिमेंट तथा खेत प्रयोग (बनारपाल, अंगुल), जो कि रबी के दौरान सूरजमुखी और सरसों की फसलों की पैदावार पर शुद्ध जल के संयोजन के साथ औद्योगिक अपशिष्ट जल का उपयोग करने के प्रभाव का मूल्यांकन करने के लिये किया गया। इस प्रयोग से यह परिणाम प्राप्त हुआ कि केवल 100% अपशिष्ट जल सिंचाई की तुलना में 75% अपशिष्ट जल और 25% शुद्ध जल के संयोजन का उपयोग अधिक फसल वृद्धि और उपज के लिये लाभदायक साबित हो सकता है।

प्रदूषित जल स्रोतों से क्रोमियम का बायोरीमेडिएशन : ओडिशा राज्य के सुकिंदा में क्रोमाइट खान के क्षेत्रों से एकत्रित 70% जल के नमूने और 28% मृदा के नमूने क्रोमियम की विषाक्तता से ग्रसित थे और कृषि में उपयोग के लिये असुरक्षित थे। वाटर कल्चर अध्ययन से पता चला कि जलीय पौधों में से आइपोमिया एक्वाटिका पौधा 2.0 मिलीग्राम/लीटर क्रोमियम की सांद्रता के बाद अधिक संवेदनशील है जबकि साल्विनिआ मिनिमा को 2.8 मिलीग्राम/लीटर तक सहिष्णु पाया गया। साल्विनिआ मिनिमा अन्य तीन जलीय पौधों जैसे पिस्टिया स्ट्रैटियोट्स, इपोमिया एक्वाटिका एवं इकोर्निया क्रेस्सिप्स की तुलना में 5 से 7 गुणा अधिक क्रोमियम का संचय कर सकता है और इसका बायोरीमेडिएशन के लिए प्रयोग किया जा सकता है।

कृषि जल प्रबंधन पर वेब-आधारित विशेषज्ञ प्रणाली का विकास : कृषि जल प्रबंधन पर एक वेब-आधारित विशेषज्ञ प्रणाली विकसित की गई जिसमें कृषि, बागवानी, मत्स्य पालन और पशुपालन आदि भी शामिल हैं।

दूरस्थ पंप संचालन हेतु मोबाइल ऐप का विकास : इस संस्थान के वैज्ञानिक ने एक मोबाइल ऐप विकसित किया जो कि दूरस्थ जगह से भी पंप को संचालित करने के लिये सक्षम है।

महात्मा गाँधी राष्ट्रीय ग्रामीण रोजगार गारंटी योजना (एमजीएनआरईजीएस) के तहत जल से संबंधित तकनीकों का सामाजिक-आर्थिक मूल्यांकन : ओडिशा राज्य में वर्ष 2014-15 और वर्ष 2017-18 की तुलना से वर्ष 2015-16 में इस योजना के तहत व्यय लगभग दोगुना हो गया। यदि प्राकृतिक संसाधन प्रबंधन (NRM) और कृषि कार्यों के व्यय पर विचार किया जाये तो वर्ष 2014-15 तक कृषि में पूरा व्यय प्राकृतिक संसाधन प्रबंधन पर ही था। लेकिन उसके बाद कृषि और इसके संबंधित कार्यों तथा प्राकृतिक संसाधन प्रबंधन कार्यों पर व्यय के अनुपात के बीच भिन्नता पायी गई। यह अध्ययन इस

बात को इंगित करता है कि ओडिशा में जल से जुड़े लोगों सहित प्राकृतिक संसाधन प्रबंधन कार्यों को प्राथमिकता नहीं मिल रही है।

बेहतर जल प्रबंधन तकनीकों पर प्रशिक्षण/खेत में प्रदर्शन के माध्यम से आदिवासी किसानों की आजीविका में सुधार : ओडिशा राज्य के सुंदरगढ़ जिले में सदर ब्लॉक के बिरजाबर्ना गाँव में ट्राइबल सब प्लान (TSP) परियोजना के तहत 'पंप संचालन, रख-रखाव और सिंचाई जल प्रयोग की तकनीकों पर एक खेत प्रदर्शन-सह-प्रशिक्षण कार्यक्रम आयोजित किया गया। इस प्रशिक्षण कार्यक्रम के दौरान विभिन्न सिंचाई जल प्रयोग की तकनीकों, विभिन्न फसलों में सिंचाई जल प्रयोग विधियों पर खेत प्रदर्शन, कृषि आय को बढ़ाने के लिये फसल एवं जल की आवश्यकता, और मछलीपालन की विधि को विभिन्न परिवारों को बताया गया। बाढ़ सिंचाई विधि की बजाय पाइप सिंचाई प्रणाली को अपनाने हेतु प्रोत्साहित करने के लिये सिंचाई स्रोत वाले कुल 24 आदिवासी किसानों को क्विक एक्सन कप्लर के साथ एचडीपीई पाइप प्रदान करके दो टीएसपी गाँवों में पाइप निर्वहन सुविधा प्रदान की गई।

फारमर्स फर्स्ट प्रोजेक्ट : धान की खेती की तकनीकों में पंक्ति में रोपण, धान गहनता पद्धति, उर्वरकों की उचित मात्रा और कोनो-वीडर के उपयोग को शामिल किया गया । इसके अलावा, फसलों की उत्पादकता और किसानों की आय को बढ़ाने के लिये वहाँ के किसानों को बैंगन की पौध और मछली की फिंगरलिंग्स को वितरित किया गया।

वैज्ञानिक तकनीकों के माध्यम से गाँव के तालाब का पुन:निर्माण : इस परियोजना के तहत स्थलों का चयन किया गया और वहाँ से मृदा, जल, तालाब और जलग्रहण क्षेत्र (catchment) चित्रण आदि से संबन्धित जानकारी को एकत्रित करके सर्वेक्षण किया गया। तालाब के पुन:निर्माण के सुझाव के लिये हिस्टोरिकल सेटेलाइट छवि विश्लेषण और जलग्रहण क्षेत्र की 11 जगहों का निष्कर्षण किया गया।

सिंचाई जल प्रबंधन पर अखिल भारतीय समन्वित अनुसंधान परियोजना : भाकृअनुप-भारतीय जल प्रबंधन संस्थान, भुवनेश्वर देश के विभिन्न कृषि उप पारिस्थितिकी सब क्षेत्रों में स्थित सिंचाई जल प्रबंधन पर अखिल भारतीय समन्वित अनुसंधान परियोजना के कुल 26 केन्द्रों के लिये एक समन्वयक केंद्र के रूप में कार्य करता है। इस संस्थान के निर्देशन में इन समन्वित केन्द्रों द्वारा मृदा-जल-पौधा संबंध एवं इनकी परस्पर प्रतिक्रिया पर बुनियादी अध्ययन तथा जल की उपलब्धता का आकलन, अधिक वर्षा वाले क्षेत्रों में वर्षा जल प्रबंधन, भूजल आकलन एवं पुनःभरण, दवाब सिंचाई प्रणाली का मूल्यांकन, बागवानी एवं अधिक मूल्य वाली फसलों में जल प्रबंधन, नहरी जल एवं भूजल का संयोजी उपयोग, अपशिष्ट जल का सिंचाई के लिये प्रयोग तथा जल की उत्पादकता बढ़ाने के लिये जल निकासी अध्ययन आदि विषयों पर प्रचार-प्रसार का अनुसंधान किया जाता है।

जल पर कृषि भागीदारी अनुसंधान मंच : भाकृअनुप-भारतीय जल प्रबंधन संस्थान जल पर कृषि भागीदारी मंच के लिए एक समन्वयक केंद्र के रूप में काम कर रहा है। इस अनुसंधान मंच के तहत कुल 6 परियोजनाएँ चल रही है, जो कि इस प्रकार है: भारत के विभिन्न कृषि पारिस्थितिकी क्षेत्रों में एकीकृत जल संसाधन विकास एवं प्रबंधन; स्वतः सिंचाई एवं ड्रिप-सिंचित केला की फसल में फर्टीगेशन; कृषि क्षेत्रों में अपशिष्ट जल के पुन: उपयोग के लिये विशेष उपाय; विभिन्न मछलीपालन उत्पादित पद्धतियों में जल के बहुआयामी उपयोग द्वारा जल बजट तथा जल उत्पादकता बढ़ाना; नहरी कमाण्ड क्षेत्र में सिंचाई पद्धति का मूल्यांकन तथा अधिक जल उत्पादकता में सुधार के लिये तकनीकी उपाय; तथा कृषि में जल के उपयोग को नियंत्रित करने के लिये संस्थागत एवं विपणात्मक नवाचार।

प्रकाशन, पुरस्कार एवं सम्मान : भाकृअनुप-भारतीय जल प्रबंधन संस्थान के वैज्ञानिकों ने वर्ष 2017-18 के दौरान कुल 43 शोध पेपर, 10 पुस्तकें/बुलेटिनों/प्रशिक्षण मैन्युअल एवं 5 लोकप्रिय तकनीकी लेख प्रकाशित किये। भाकृअनुप-भारतीय जल प्रबंधन संस्थान, भुवनेश्वर को कृषि जल प्रबंधन के क्षेत्र में आईएसओ 9001: 2015 प्रमाणित शोध संस्थान के रूप में पहचाना गया है। हमारे संस्थान के वैज्ञानिकों ने 'उत्कल दिवस सम्मान-2017', देश के प्रतिष्ठित राष्ट्रीय सोसाइटी और अकादमियों द्वारा 'फेलो पुरस्कार', 'युवा वैज्ञानिक पुरस्कार', 'कृषि विज्ञान गौरव पुरस्कार-2017', 'स्वच्छता पुरस्कार' आदि कई अन्य सम्मान और पुरस्कार प्राप्त किये।

अनुसंधान परियोजनायें : भाकृअनुप-भारतीय जल प्रबंधन संस्थान के वैज्ञानिक कुल 20 संस्थान के अनुसंधान परियोजनाओं तथा 10 बाहरी वित्त-पोषित अनुसंधान परियोजनाओं के साथ-साथ पांच परामर्श परियोजनाओं पर कार्य कर रहे हैं।

प्रशिक्षण एवं क्षमता निर्माण : भाकृअनुप-भारतीय जल प्रबंधन संस्थान ने प्रधानमंत्री कृषि सिंचाई योजना (PMKSY) के तहत 10 उन्नत क्षमता निर्माण कार्यक्रमों का सफल आयोजन किया। आठ किसान-विशेषज्ञ बातचीत संबंधी सह-व्यावहारिक प्रशिक्षण कार्यक्रमों का आयोजन करके कुल 257 किसानों को लाभान्वित किया; पी एम के एस वाई के तहत तीन अंतरराज्यीय किसान प्रशिक्षण कार्यक्रमों द्वारा 59 किसानों को लाभान्वित किया गया। इसके अलावा कृषि जल प्रबंधन के विभिन्न विषयों पर सरकारी अधिकारियों तथा छात्रों के लिए कई अन्य प्रशिक्षण कार्यक्रम भी आयोजित किये गये; साथ ही साथ 8 कृषि प्रदर्शिनीयों के माध्यम से इस संस्थान द्वारा विकसित विभिन्न तकनीकियों को विभिन्न स्थानों पर प्रदर्शित किया गया।

मेरा गाँव-मेरा गौरव कार्यक्रम : भाकृअनुप-भारतीय जल प्रबंधन संस्थान के वैज्ञानिकों के छह समूहों ने मेरा गाँव-मेरा गौरव कार्यक्रम के तहत ओडिशा राज्य के पाँच जिलों (पूरी, खुर्धा, ढेंकानाल, केंद्रापाड़ा एवं जगतसिंहपुर) में स्थित 7 ब्लॉकों के 30 गाँवों को अपनाया गया। वैज्ञानिकों द्वारा इस कार्यक्रम के तहत कृषि जल प्रबंधन सहित कृषि के विभिन्न विषयों पर जागरूकता के बारे में जानकारी प्रदान की गई, तथा साथ ही साथ किसानों के लिये कई प्रशिक्षण/संगोष्ठी/ बैठकें आयोजित की गई जिससे किसानों को बहुत लाभ मिला।

स्वच्छ भारत अभियान : भाकृअनुप-भारतीय जल प्रबंधन संस्थान ने स्वच्छ भारत अभियान में सक्रिय रूप से भाग ले कर संस्थान के मुख्य परिसर, सार्वजनिक स्थानों और पर्यटन स्थलों पर वर्ष 2017-2018 के दौरान कुल 33 स्वच्छता कार्यक्रमों को आयोजित किया; छात्रों को स्वच्छता के लिये प्रेरित किया गया तथा इस वर्ष के दौरान कई वाद विवाद/सेमिनार/प्रशिक्षण कार्यक्रम भी आयोजित किये गये।

EXECUTIVE SUMMARY

Executive Summary

Water and nutrient self-reliant farming system for rainfed areas : The net return from the self-reliant farming system (₹ 131510 from 1.5 ha area) was higher by 3.4 and 3.0 times than traditional rice-fallow and rice-utera (black gram) cropping systems, respectively. Water productivity for the system (₹ 13.2 m^{-3}) was also higher by 4.5 and 4.1 times, respectively compared to traditional rice-fallow and rice-utera (black gram) cropping systems.

Drainage planning of eastern coast delta : Drainage planning of eastern coast delta (Bhargabi-Daya doab) was done using geo-informatics tool. The drainage density needs to be increased to at least 0.50 which can be created with additional drain length of 330 km in the doab. Desilting of existing drains and streams are to be taken up. Around 3.4% area in which majority of the water bodies are weed infested or silted needs to be renovated for storing good quality water and providing irrigation. A crop planning has also been suggested for these area.

Lessening water use in monoculture of Pacific white shrimp : In Pacific white shrimp(*Litopenaeus vannamei*) culture, with best management practice at the optimum stocking density of 5 lakh shrimp seed ha^{-1}, total water use and water exchange could be minimized to 33,300 and 6,300 m^3 ha^{-1} respectively, without hampering growth and production. With this stocking density, shrimp productivity enhanced to a level of 10.4 t ha^{-1} in 120 d. Further, using this technique, net income of ₹ 78.3 could be generated per m^3 of water and 1.84 m^3 water is required to produce one kg of shrimp.

Enhancing pulse productivity using micro-irrigation : Sprinkler irrigation at two critical crop growth stages of greengram i.e., flowering and pod formation resulted in highest water productivity compared to single stage irrigation and control treatments. Two irrigations and N application at 20 kg ha^{-1} through urea and Rhizobium increased pod yield of the crop from 0.46 to 0.94 t ha^{-1} and net water productivity from ₹2.30 to 6.43 m^{-3}.

Development and evaluation of mini-pan evaporimeter for irrigation scheduling : The mini-pan evaporimeters made from galvanized iron (GI) sheet and PVC pipes with diameters of 10, 20 and 30 cm, and height of 25 cm. The scatter plot of evaporation from PVC and GI mini pan evaporimeters with USWB open pan showed that the evaporation from 30 cm GI mini pan had highest relationship (R^2 = 0.95) with evaporation from USWB open pan than other mini pans.

Land shaping options for enhancing income in coastal waterlogged area : This project has been initiated, initial socio-economic survey and water level of selected sites has been monitored to plan appropriated land shaping.

Study on global yield gap of rice and wheat : The potential yields, actual yields and yield gap trend of different climatic buffer zones of India were estimated using APSIM model. The yield gap of rice ranged from 52.6% in Patiala (Punjab) to 83.4% in Patna, Bihar and the yield gap of wheat ranged from 22.5% in Patiala, Punjab to 68.2% in Palampur, Himachal Pradesh.

Index-based flood insurance (IBFI) and post-disaster management : Flood damage was assessed for agricultural crops in Muzaffarpur district of Bihar during *kharif* season and post-flood management plan was prepared and implemented in flood prone areas. Crop management interventions such as double transplanting method of rice (*Kharuhan*), deep waterlogging resistant varieties like *'Varsha Dhan'*, over-aged rice seedlings (60 d old) and water chestnut based farming system have been suggested to provide better resilience in flood-prone fragile ecosystem.

Improving irrigation efficiency in canal command : The created available water resources through the canal linked service reservoir and dug well based sprinkler irrigation was used for crop production at Ghurlijore minor irrigation command, Sundargarh. The created irrigation infrastructures yielded 3.6 t ha^{-1} of paddy crop with water productivity of 0.29 kg m^{-3} using rainwater and supplemental irrigation water from service reservoir. The introduction of sprinkler irrigation system helped producing 12.5% higher yield with 40% less water use, resulting in 87% higher water productivity compared with check basin irrigation in groundnut. Due to the interventions, the irrigation intensity has been enhanced by 164% and average annual net income in the target area increased from ₹ 17800 ha^{-1} to ₹ 178000 ha^{-1}.

Computed virtual water footprint : Water footprints of rice is likely to increase by 2.5, 4.3-7.1 and 9.4-11.3% in 2050, 2070 and 2090, respectively under RCP 8.5 scenario in the Punjab, Odisha and Tamil Nadu. Micro-irrigation is another option for reduction of water footprints in agriculture. Through dug-well based drip irrigation system in hard rock areas of Dhenkanal, 51.5, 63.8 and, 63.9% water footprints were reduced when drip was applied at 80% ETc to cauliflower, potato and chili, respectively than that of surface irrigation system (1.0 IW/CPE).

Evaluation of rice cultivation methods and water saving irrigation : Field trials showed that performance of rice was similar with direct wet-seeding and puddled transplanting methods during *kharif* as well as *rabi* / summer season. Alternate wetting and drying (AWD), and irrigation at 3-days after disappearance (3-DAD) of water were compared with continuous flooding (CF) during *rabi* / summer season. Grain yield was statistically similar in all irrigation treatments viz. CF, 3-DAD and AWD; water saving was about 22% in 3-DAD and 28% in AWD compared to CF. Consequently, water productivity increased by 27 and 38% in 3-DAD and AWD, respectively over CF. Hence, two methods viz. AWD and irrigation at 3-DAD hold promise with significant saving of irrigation water for rice farming in the region.

Benchmarking for assessing the performance of canal irrigation system : Water auditing data of Maharashtra state was analyzed for major and medium irrigation projects. Several indicators such as water availability in reservoirs on 15th October, % of actual evaporation to live storage on 15th October, target and actual irrigation potential utilization, water use pattern, irrigation system performance, ratio between planned and actual non-irrigation uses, ratio between unutilized water and live storage on 15th October, conveyance efficiency of main canals, and actual cropping pattern were used for this analysis.

Impact of super absorbent polymers (SAP) on crop growth of rice and groundnut : A field experiment was conducted to evaluate different doses of SAP on crop growth and yield of groundnut and rice. Results show insignificant impact of different doses of SAP (0, 25, 50, 75 and 100 kg ha^{-1}) on soil properties, crop growth and physiological performances. Moreover, water productivity varied 11% and 4% amongst different levels of SAP in groundnut and rice, respectively.

Achievements under NICRA projects : Seasonal and diurnal variation in gross primary productivity, ecosystem respiration, net ecosystem exchange (NEE) of rice crop was determined using eddy covariance technique. Fertigation scheduling experiment was continued on okra and cowpea crops. Enhanced crop productivity by 53.6 and 68.9% was obtained in okra and cowpea, respectively, under drip + 100% RDF (fertigation) over surface irrigation + 100% RDF (soil application). Gain of ₹ 71811-98032 ha^{-1} $annum^{-1}$ with B:C ratio of 3.0 was obtained from water harvesting and dyke based agro-forestry system which helped to mitigate waterlogged and flood prone areas. Conjunctive use strategy through groundwater monitoring under changing climate scenarios in Brahmani river basin was also developed.

Enhancing economic water productivity in irrigation canal commands : A collaborative research project between IWMI, Colombo, ICAR-IIWM & AICRP (IIWM), Rahuri (Maharashtra) was taken up for increasing the economic water productivity sustainably in command area of Sina medium irrigation command in the state of Maharashtra. Benchmarking data (2001-2011) shows about some of the indicators that canal system is over-performing, while others indicate it is under-performing referring state norm of 2009. Systematic asset management

(SAM) tool is under developmental process for ascertaining the irrigation infrastructure functioning in the command area.

Intensive horticultural system in degraded land : To improve water productivity and generate profits from degraded land, an experiment was conducted in pre-bearing mango orchard intercropped with papaya and pineapple under drip irrigation and paddy straw mulch. No significant differences were observed in vegetative growth. However, yield / pineapple equivalent yield in mango intercropped with pineapple under straw mulch (17.5 t ha^{-1}) as well as water productivity in the system (21.1 kg ha-mm^{-1}) was significantly higher compared with other cropping systems.

Socioeconomic and environmental linkages of groundwater irrigation : Two intensely groundwater irrigated districts, such as the east and west Godavari districts, were assessed to understand the socioeconomic and environmental linkages of groundwater irrigation. In order to meet the increased evaporative demands of atmosphere, groundwater has played a pivotal role in the summer rice cultivation. Consequently, water tables have dropped faster in the west Godavari district particularly. The Government's policy appears to be the catalyst of resource loss, but a social gain as millions of small farmers have been benefited.

Design of groundwater recharge structures for hard rock areas : Potential areas for construction of groundwater recharge structures were delineated for 637 ha Bargharianala micro watershed located in Daspalla block of Odisha. Recharge well (1.2 m diameter, 12 m depth) was constructed in rainwater harvesting structure in Srirampur village. The impact of recharge structures revealed that the rise in water table depth up to 0.7 m in dug-wells located within the area of influence (15 ha area) of the structures. Groundwater recharge was estimated as 5.7 cm $year^{-1}$ for the area.

Assessment of groundwater contamination in lower Godavari basin : Lower Godavari basin is one of the most fertile and intensively cultivated area in India. Using ASTER and DEM data from USGS earth explorer and CGWB physiography, groundwater depth and quality were assessed and chemical analysis of water showed nitrate contamination in northern part of the basin.

Efficient groundwater management under climate change in sugarcane farming system : The groundwater budgeting of the RasulpurJattan village of Muzaffarnagar district, UP indicates that groundwater storage for the village was (-) 651063 m^3 which estimates the annual fall in groundwater table as 1.36 m against the observed data of 0.35 m at nearby Kakada village. The future climatic data was analyzed using MarkSim Global Climatic Model (GCM) at Representative Concentration Pathway (RCP-4.5). The future water demand at decadal interval was assessed for different scenarios. The scenarios are formulated considering the area under sugarcane, improved water conveyance and application method, number of recharge structures etc. Finally the water availability was compared with the water demand and the groundwater table was predicted for different scenarios.

Impact of industrial wastewater on oilseeds crop : Assessment of surface water quality of Angul industrial area in Odisha revealed that most of the effluents from the industries were discharged during the monsoon season makes it unsuitable for use as irrigation to crops. A pot experiment as well as on-farm field in Banarpal, Angul were conducted to evaluate impact of using industrial wastewater in conjunction with freshwater on yield of sunflower and mustard crops during *rabi* season. The conjunctive use of 75% wastewater and 25% freshwater showed significantly higher crop growth and yield attributes than 100% wastewater irrigation.

Bioremediation of chromium from polluted water sources : 70% of water samples and 28% soil samples collected from chromite mine areas in Sukinda, Odisha had chromium [Cr (VI)] toxicity, and unsafe for use in agriculture. Water culture study shows that aquatic plants - *Ipomoea aquatica* is susceptible beyond 2.0 mg l^{-1} while *Salvinia minima* has found tolerant up to 2.8 mg l^{-1} in water. *Salvinia minima* could accumulate 5 to 7 folds more [Cr (VI)] than other three aquatic plants- *Pistia stratiotes, Ipomoea aquatica* and *Eichhornia crassipes.*

Development of web-based expert system on agricultural water management : A web-based expert system on agricultural water management has been developed including agriculture, horticulture, fisheries and animal husbandry.

Development of mobile App for remote pump operation : A mobile App has been developed to operate pump remotely.

Socio-economic evaluation of water related interventions under MGNREGS : In Odisha, expenditure under MGNREGS almost doubled in 2015-16 as compared to 2014-15 and in 2017-18. If expenditure on NRM and agriculture works is considered, till 2014-15 the entire expenditure in agriculture was on NRM. But afterwards there was divergence between proportion of expenditure on agriculture & allied works and NRM works. This preliminary study indicates that NRM works including water related ones are not receiving due priority in Odisha.

Livelihood improvement of tribal farmers through training/ field-demonstration on improved water management practices : A field demonstration-cum-training program on 'Pump operation, maintenance and irrigation application techniques' was conducted at Birjaberna village in Sadar block, Sundargarh under TSP project. Different irrigation water application techniques, field demonstration on water application methods in different crops, crop water requirement and aquaculture practices to enhance the farm income were also briefed to the famers during the training program. Pipe conveyance facility was extended in two TSP villages by providing HDPE pipes with quick action coupler to 24 tribal farmers having irrigation sources for encouraging to adopt pipe irrigation system instead of flooding irrigation.

Farmer's FIRST Project : Line transplantation, SRI method, application of proper doses of fertilizers and use of cono-weeder were included in the intervention in rice cultivation. Also, brinjal seedlings and fish fingerlings were distributed to the farmers for enhancing productivity and income.

Revival of village ponds through scientific interventions : Under this project, sites were selected, survey were done for collecting information about soil, water, ponds and catchment delineation. Historical satellite image analysis and extraction of elevation values of the catchment were done to suggest revival of ponds.

AICRP on Irrigation Water Management : ICAR-IIWM acts as a coordinating center of twenty six centers of AICRP-IWM to carry out basic studies on soil, water, plant relationship & their interaction and extension work in the field of assessment of water availability, rainwater management in high rainfall areas, enhancing productivity by multiple use of water, groundwater use at regional level, groundwater assessment and recharge, evaluation of pressurized irrigation system, water management in horticultural and high value crops, conjunctive use of canal and groundwater, and drainage studies for enhancing water productivity. Significant finding from different centers are presented.

Agri-CRP on Water : ICAR-IIWM acts as a coordinating center of Agri-CRP on Water and six research projects are continued at this institute namely-Development and management of integrated water resources in different agro-ecological regions of India; Evaluation of irrigation system and improvement strategy for higher water productivity in canal commands; Automatic irrigation and fertigation in drip-irrigated banana; Eco-friendly wastewater treatment for re-use in agri-sectors: Lab to land initiative; Water budgeting and enhancing water productivity by multiple use of water in different aquaculture production systems; and Institutional and marketing innovations governing use of agriculture water.

Publication, awards and recognitions : During 2017-18, scientists of ICAR-IIWM published 43 peer reviewed research papers, 10 books / bulletins / training manuals and 5 popular articles. ICAR-IIWM has been recognized as ISO 9001:2015 certified research institute in the field of Agricultural Water Management. Our Scientists have received *Utkal Diwas Samman*-2017, Fellow Award by prestigious national Societies and Academies in the country, young scientists award, *Krishi Vigyan Gaurav*-2017, *Swachhata Puraskar*, along with many others honours and recognitions.

Research projects : Scientists of ICAR-IIWM working on 20 in-house and 10 externally-funded research projects along with five consultancy projects.

Training & capacity building : ICAR-IIWM conducted ten advanced capacity building program under PMKSY; eight farmers-expert interaction cum-practical training programs benefitting 257 farmers; three inter-state farmers training program under PMKSY benefitting 59 farmers; and several other training programs for government officials / students on various topic of agricultural water management; eight exhibitions to showcase ICAR-IIWM technologies.

***Mera Gaon Mera Gaurav* :** Six groups of scientists of ICAR-IIWM adopted 30 villages across 7 blocks spreading over 5 districts of Odisha under the *'Mera Gaon Mera Gaurav'* program. Scientists of ICAR-IIWM provided information on awareness on various areas in agriculture to the farmers of adopted villages and conducted several trainings/ interaction meetings.

***Swachh Bharat Abhiyan* :** ICAR-IIWM participated actively in *Swachh Bharat Abhiyan* and 33 number of cleanliness campaigns were conducted during 2017-2018 in the Institute main campus, public places and tourist spots; motivated students for cleanliness; organized debate, seminars and trainings.

CONTENT

Content

INTRODUCTION

Introduction

The ICAR-Indian Institute of Water Management (erstwhile Directorate of Water Management or Water Technology Centre for Eastern Region) was established on May 12, 1988 with the aim to cater the research and development need of agricultural water management at national level. The institute is located at Chandrasekharpur, Bhubaneswar on a 5.71 ha of land along with its main office-cum-laboratory building, guest house and residential complex. It is situated about 8 km north of Bhubaneswar railway station and at about 15 km away from Biju Patnaik International Airport, Bhubaneswar. The location of the Institute is at 20°15' N and 85° 52' E at 23 m mean sea level. The research farm of the Institute (63.71 ha of farm land) is located at Deras, Mendhasal (20°30' N and 87°48' E) and is 30 km away from main institute complex.

MANDATE

- Strategies for efficient management of non-farm water resources for sustainable agricultural productivity
- Co-ordinate research for generating location-specific technologies for efficient use of water resources
- Centre for training in agricultural water management

Research achievements

Core research activities of the institute are carried out under four programs, viz., rainwater management (including waterlogged area management), canal water management, groundwater management and on-farm technology dissemination (including wastewater management, water policy & governance) to solve the agricultural water management related problems. The institute has experienced multi-disciplinary team of scientists.

Significant research achievements for the year 2017-18 include development of drainage plan for Mahanadi delta and computing virtual water and water trade potential for agro-based products. There has been a considerable research work conducted towards development of runoff water recycling, and land modification/shaping technique for enhancing productivity, water and nutrient self-reliant farming system for rainfed areas; climate resilient agriculture, groundwater management for enhancing adaptive capacity to climate change, design of groundwater recharge structures for hard rock areas, assessment of groundwater contamination and its management in lower Godavari basin, options for enhancing irrigation efficiency and development of integrated farming systems in canal commands, and water saving techniques in rice and pulse crop. With the aim of water budgeting and enhancing water productivity in aquaculture systems, stocking density of pacific white shrimp culture has been optimized. For management of waterlogged areas, drainage planning of eastern coast delta and optimal cropping pattern; index-based flood insurance and post-flood disaster management has been suggested. Studies are being carried out for bioremediation of polluted water, impact assessment of industrial wastewater, development and evaluation of mini-pan evaporimeter for irrigation scheduling, intensive horticultural system for improving farm income from degraded land, social and sustainability implications of water management interventions. A substantial work has been done for livelihood improvement of tribal farmers through water management intervention and revival of village ponds through scientific intervention. Our institute has also initiated development of web-based expert system on agricultural water management.

Under the *Pradhan Mantri Krishi Sinchayee Yojana* (PMKSY) of the Government of India, Institute has played a major role in capacity building for project implementing agencies of GoO and for farmers of Bihar. In addition to research and development efforts at the Institute level, different agricultural water management related issues at the regional level are being addressed by different centres under the AICRP on Irrigation Water Management. Through ICAR-Agri-Consortia Research Platform on Water project, institute has successfully installed rubber dams in different agro-ecological regions of India, initiated improvement strategies for higher water productivity in canal commands, drip-irrigation in horticultural crops, eco-friendly wastewater treatment, multiple use of water in aquaculture production systems, addressing issues related to water governance and policy. With the aim of dissemination of technology and working with farmers, Scientists are involved with thirty adopted villages across seven blocks in Odisha under *Mera Gaon Mera Gaurav* (MGMG) programme; conducted training programs for Government officials, farmers and students on various aspects of water management, conducted *Krishi Unnati Mela*, and participated in exhibitions to showcase technologies developed by the institute.

Infrastructure facilities and organization

The institute has state-of-the-art infrastructure facilities and has four well-equipped laboratories, viz., soil-water-plant relationship laboratory, irrigation and drainage laboratory, hydraulic laboratory, and plant science laboratory with all the latest equipment for research activities. An engineering workshop also cater to the needs of the institute. Four field laboratories at farm, viz., meteorological laboratory, pressurized irrigation system, solar photovoltaic pumping system, and agricultural drainage system also add to the research related inputs. The institute has a state of-the-art communication facility with an automatic EPABX system and LAN. The institute has its own web server and regularly updated website (www.iiwm.res.in). The entire network administration of the computers, internet and website management is looked after by the ARIS cell. The ARIS cell also accommodates a fully developed GIS laboratory. The air-conditioned library of the Institute has more than 2000 reference books and subscribes to 14 international and 6 national journals. It has a CD-ROM Server with bibliographic, database from AGRIS, AGRICOLA and Water Resources Abstracts. The subscription of electronic journals and its access through LAN to all the scientists is another useful facility of the library. The installed video conferencing and IP Telephony System facility at the Institute is being utilized for related use from time to time.

The ICAR-IIWM has linkages with various agencies through providing training, consultancy, collaboration or contract research services. It has provided a platform for public and private sector institutions dealing with water management research to address their scientific problems, monitor research and development activities and their evaluation in a cost effective manner. The institute has developed linkages with different state and central government agencies like Watershed Mission (Government of Odisha), Directorate of Agriculture (Government of Odisha), Central and State Ground Water Board, Command Area Development Agency, Government of Odisha, WALMI, ORSAC to implement farmer friendly water management technologies in the region. In addition to ongoing in-house research projects, the institute is awarded with many sponsored /collaborative projects by various organizations like Ministry of Agriculture, GOI; IWMI, Colombo; DST and consultancy project by World Vegetable Centre-ICRISAT, Andhra Pradesh; Directorate of Soil Conservation & Watershed Development, Govt. of Odisha, Bhubaneswar and ATMA units of Bihar for providing trainings under PMKSY. The institute is coordinating center for AICRP on Irrigation Water Management and ICAR- Agri-Consortia Research Platform on Water, ICAR, New Delhi. Also, ICAR-IIWM has conducted ICAR entrance examinations for UG, PG, JRF and SRF at national level.

Finances

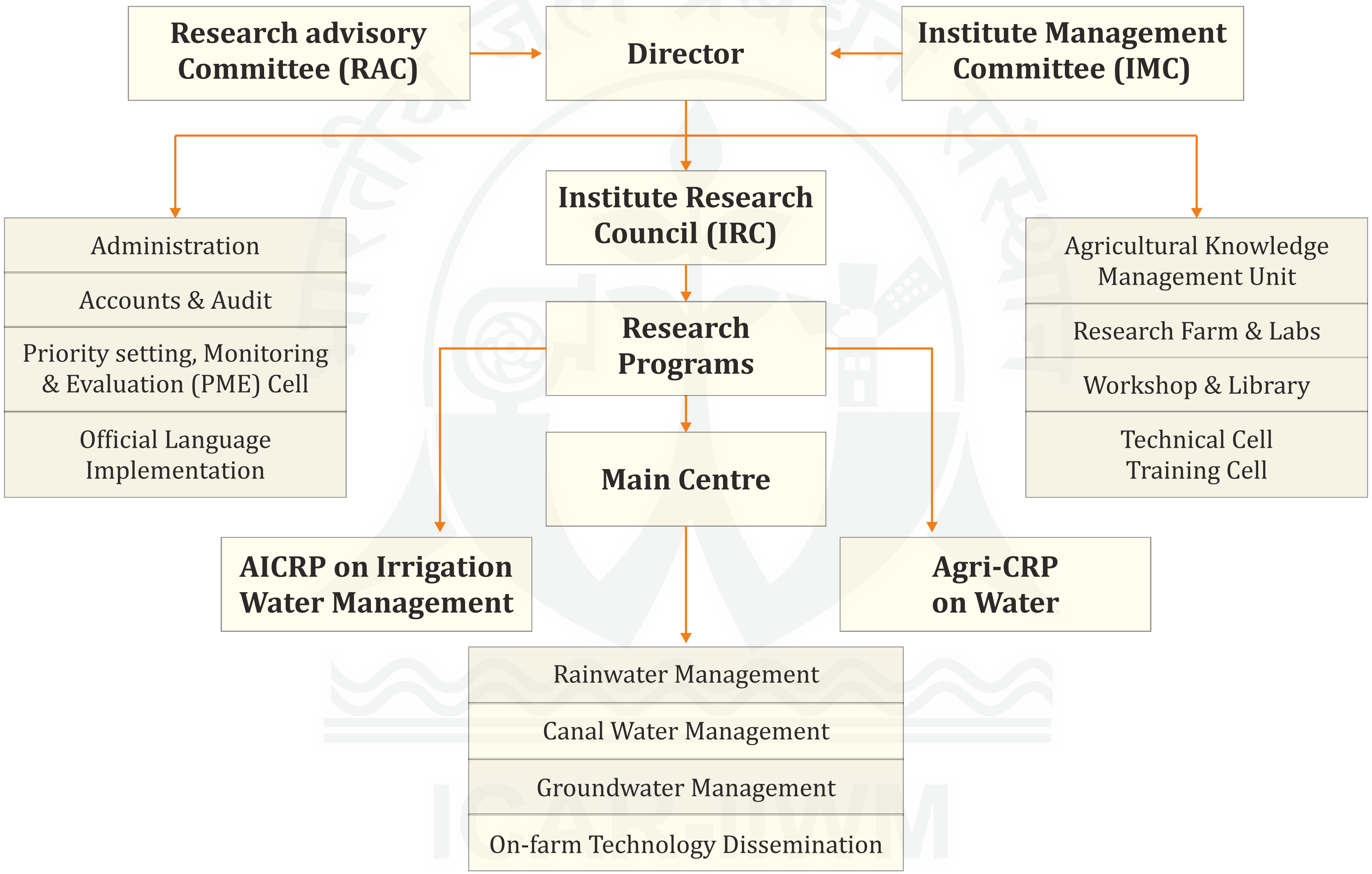
Summary of fund allocation and expenditure of the institute during the year 2017-18 is presented at the end of this report.

Staff

At the end of March 2018, ICAR-IIWM had 80 sanctioned posts (including AICRP-IWM) out of which 59 are in position. The breakup of the posts under different categories is given below:

Cadre	Sanctioned	In Position	Vacant
RMP	01	01	nil
Scientific	35	31	04
Administrative	16	12	04
Technical	17	11	06
Supporting	11	04	07
Total	80	59	21

ORGANOGRAM


Research advisory Committee (RAC)
Director
Institute Management Committee (IMC)
Administration
Accounts & Audit
Priority setting, Monitoring & Evaluation (PME) Cell
Official Language Implementation
Institute Research Council (IRC)
Agricultural Knowledge Management Unit
Research Farm & Labs
Workshop & Library
Technical Cell
Training Cell
Research Programs
Main Centre
AICRP on Irrigation Water Management
Agri-CRP on Water
Rainwater Management
Canal Water Management
Groundwater Management
On-farm Technology Dissemination

RAINWATER MANAGEMENT

Rainwater Management

This program includes research projects on rainwater management & waterlogged area management

Water and Nutrient Self-reliant Farming System for the Rainfed Farmers in High Rainfall Zone

Project Code : IIWM/15/168

Investigators : S.K. Rautaray, S. Mohanty, S. Raychaudhuri, R.K. Mohanty, R. Dubey and S. Pradhan

Identification of suitable dry season crops for self-reliant farming system

Blackgram, cowpea, groundnut, maize, cabbage, and *utera (*black gram) were grown to identify suitable crop(s) for the dry season. Yield was highest for cabbage followed by cowpea grown as vegetable crops with yield recorded on fresh weight basis (Table 1). Among other crops, the highest yield was noted for maize (3.2 t ha^{-1}) followed by groundnut (1.6 t ha^{-1}). Net Return was the highest for cabbage (₹ 54370 ha^{-1}) followed by cowpea. Among crops for seed purpose, highest net return was noted for groundnut crop (₹ 33127 ha^{-1}). Net energy was the highest for maize (35.69 GJ ha^{-1}) followed by groundnut (19.33 GJ ha^{-1}). In order to rank crops for their suitability to self-reliant farming system in dry season, an index was prepared. Relative weightage was 0.4 for plant parameters, 0.3 for soil resource parameters and the remaining 0.3 for economic parameters. This has been modified in our study assigning the relative weightage of 0.3 for plant properties, while soil properties, economics, and energy use were assigned with 0.2 each considering the value of net energy as well as water savings. The relative weightage of 0.1 was assigned for the amount of water used. Vegetable cowpea was ranked as the best suitable crop followed by groundnut.

Table 1. Yield, economics, energy and water use of selected crops under self-reliant farming system in dry season

Treatments	Yield (t ha^{-1})	Net Return (₹ha^{-1})	Energy input (GJ ha^{-1})	Net Energy (GJ ha^{-1})	Water use (mm)	*Index	Ranking
Black gram	0.97	26755	7.37	6.89	173	4.56	3
Cabbage	22.03	54370	12.28	5.34	290	3.83	5
Cowpea	9.17	47145	12.86	4.56	309	4.92	1
Groundnut	1.62	33127	11.05	19.33	309	4.68	2
Maize	3.2	6250	11.35	35.69	309	2.41	6
*Utera** blackgram*	0.22	5660	1.72	1.51	13	4.44	4

*Index considering plant properties (0.3), soil properties (0.2), economics (0.2), energy (0.2) and water use (0.1).
**Utera blackgram was grown under the residual of inorganic and organic nutrition.

Reduction of energy use in rice crop under self-reliant farming system

Energy use for rice crop under the self-reliant farming system was 6.24 GJ ha^{-1} as compared to 10.2 GJ ha^{-1} under the conventional system. This was due to substitution of inorganic fertilizers with Sesbania green manure (58 kg N, 10 kg P_2O_5 and 19 kg K_2O ha^{-1}) and vermicompost (22 kg N, 30 kg P_2O_5 and 21 kg K_2O ha^{-1}), and also due to less labour used for weeding in *Sesbania* incorporated plots. The energy used for raising *Sesbania* was very low compared to manufacture of chemical fertilizers, especially for N requiring 61 MJ energy for 1 kg fertilizer. The energy input for rice cultivation was partitioned as renewable and non-renewable energy from sustainability point of view. The non-renewable energy use was 1.93 GJ ha^{-1} under the self-reliant farming system. It was 74% less as compared to the conventional farming (7.49 GJ ha^{-1}). Renewable energy accounted 69% of the total energy input for rice cultivation under the self-reliant farming system indicating the sustainability of the practice. In case of conventional practice renewable energy input was only 26%.

Economics of the self-reliant farming system

Green manuring with *Sesbania* 14.1 t ha^{-1} (58:10:19 N: P_2O_5:K_2O) and vermicompost 3 t ha^{-1} resulted in 4.3 t ha^{-1} rice grain in *kharif* 2017. The net return was worked out as ₹ 26063 ha^{-1} (Table 2). After harvest of rice, dry season crops (cabbage and cowpea as vegetables, groundnut as oil seed, blackgram as pulse and maize for grain) were grown using vermicompost. The mean net return from these dry season field crops was ₹ 23169 ha^{-1}. Water harvesting farm pond (3894 m^2) provided a net return of ₹28488 from fish and ₹ 5000 from lotus. Papaya and banana grown on pond dyke (4.5 m wide at top) with drip irrigation resulted in net return of ₹ 49272 per annum. The net return of self-reliant farming system was ₹ 131510 from 1.5 ha area (₹ 87675 ha^{-1}). The net return from *kharif* rice was ₹ 26063 ha^{-1} and ₹ 2693 for blackgram grown as *utera* crop in dry season. Thus, the income from the self-reliant farming system was 3.4-times higher than the rice-fallow and 3-times higher than the rice-*utera* black gram cropping system.

Table 2. Net returns per annum from self-reliant farming system vs Rice-*utera* blackgram cropping system

Farming/cropping System	Components	Area (m^2)	Net return (₹)	Remarks
Self-Reliant Farming System	Rice	10000	24239	Rice in *kharif* season
	Dry season crops	10000	23169	Vegetables, groundnut, black gram, arhar and maize
	Water harvesting pond	3894	33488	₹ 28488 from fish and ₹ 5000 from lotus
	Pond dyke	882	49272	₹ 14907 from 80 papaya plants and ₹ 34365 from 180 banana plants
	Dyke slope	224	1342	Hybrid napier fodder
	Total	15000	131510	Equivalent net return of ₹ 87675 ha^{-1}
Rice-*Utera*	Rice	10000	26063	
	Utera blackgram	10000	2693	
	Total	10000	28756	3-times higher net return under SRFS *vs* rice-*utera*

Water productivity of the self-reliant farming system

Economic water productivity for the self-reliant farming system was high (₹ 13.20 m^{-3}). This was due to multiple use of water for fish, lotus, on-dyke crops and field crops. Water productivity was 4.5 times higher as compared to the prevailing practice of rice-fallow system (₹ 2.90 m^{-3}) and 4.1 times higher as compared to the rice-*utera* cropping system using blackgram (₹ 3.20 m^{-3}).

Components of self-reliant farming system

Drainage Planning of Eastern Coast Delta using Geoinformatics

Project Code : IIWM/15/169

Investigators : S.K. Jena, S. Roy Chowdhury, P.S. Brahmanand and A.K. Nayak

Drainage planning of Bhargabi-Daya doab which falls in waterlogged areas of eastern India was undertaken. Analysis of Indian remote sensing satellite images for generation of land use/ land cover including surface water bodies of the Bhargabi-Daya doab of Mahanadi delta was done. The digital elevation data of ASTER (Advanced space borne Thermal Emission and Reflection radiometer) Global DEM (digital elevation model) was obtained from United State Geological Survey (USGS) earth explorer database. The contour map for the study area was prepared.

Improvement of drainage conditions in the study area by constructing surface drains is required. This would reduce the drainage congestion problems and water logging. The estimated drainage density needs to be increased to at least 0.50, and another drain length of 330 km is necessary for evacuation of excess water. As altogether construction of new surface drains may be difficult for the whole length, renovation of already existing silted drains and streams may be taken up as immediate measure. The existing small sluice along the left bank and right bank of river Bhargabi generally remain closed during monsoon and are opened during post-monsoon when water is released from Mahanadi barrage. The drains emerging from those gates are mostly silted and infested with weeds without any regular cross section lacking proper maintenance. All these drains need desilted. Depending upon the location, the end of the drain may be converted to a pond or the drain water may be directed to the sea wherever possible. The location of the origin of the streams, their length, head difference between the origin and end points were worked out.

Around 3.4% of the total geographical area of the study area is under ponds and other water bodies. But most of them are silted and weed infested with less water storage capacity. All these ponds need to be desilted and weeds to be removed. The water stored in the ponds may be used for aquaculture and irrigation of adjacent agricultural fields. The excavated earth may be used for strengthening embankments of the pond and water bodies, and acts as effective shield against floods. However, all the water congestion problems cannot be solved with surface drainage due to non-availability of fall at the outlet. Hence, with the existing condition, some crop planning is to be made. The existing net sown area, cropping intensity and cropping pattern during both *kharif* and *rabi* seasons has been analyzed for major blocks (Pipli, Delanga, Satyabadi, Brahmagiri, Kanasa and Puri Sadar) of Puri district under Daya-Bhargavi Doab. Among the blocks, Pipli recorded with the highest cropping intensity (194%) followed by Delanga (180%), whereas the lowest cropping intensity (141%) was recorded in Brahmagiri block. The existing cropping pattern reveals that rice, vegetables and chilli are dominant crops during *kharif* season whereas rice, green gram, black gram and groundnut are the dominant crops during *rabi* season. Based on the water resource and drainage scenario, optimal cropping pattern and some relevant crop management interventions have been suggested (Table 3).

Table 3. Optimal cropping pattern suggested for selected blocks of Puri district under Daya-Bhargabi doab

Name of block	Net cropped area (ha)	Cropping intensity (%)	Existing cropping pattern		Suggested cropping pattern and crop management interventions	
			Kharif	*Rabi*	*Kharif*	*Rabi*
Pipli	19,305	194	Rice/ maize/ vegetables/ chilli	Rice/black gram/ green gram/ groundnut	The area under maize and vegetables may be increased by 10%. Medium waterlogging tolerant rice varieties like Durga.	The area under green gram and groundnut may be increased by 15%. Crop diversification with sunflower and sesamum in 5% NSA. Raised and sunken bed system
Delanga	18,014	180	Rice/ vegetables/ chilli	Black gram/ green gram/ rice/ground nut	The area under maize and vegetables may be increased by 15%. Medium waterlogging tolerant rice varieties like Durga.	The area under green gram and groundnut may be increased by 20%. Crop diversification with sunflower and sesamum in 5% NSA. Sunflower, bitter gourd and sweet potato with zero tillage in post flood situation.
Satyabadi	13,398	174	Rice/ vegetables/ chilli	Rice/black gram/ green gram/ horse gram/ groundnut	The area under vegetables may be increased by 5%. Over aged rice seedlings of 60 days age. *Kharuhan* (Double transplanting) method	The area under green gram and groundnut may be increased by 10%. Raised and sunken bed system. Sunflower, bitter gourd and sweet potato with zero tillage in post flood situation.
Kanasa	17,023	154	Rice/ maize/ vegetables/ chilli	Black gram/rice/g roundnut/g reen gram	The area under maize and vegetables may be increased by 5%. Over aged rice seedlings of 60 days age. Bio-drainage with Casuarinas and Eucalyptus sp. *Kharuhan* (Double transplanting) method	The area under green gram and groundnut may be increased by 10%. Raised and sunken bed system. Spray 2% brine solution to prevent premature germination in field.

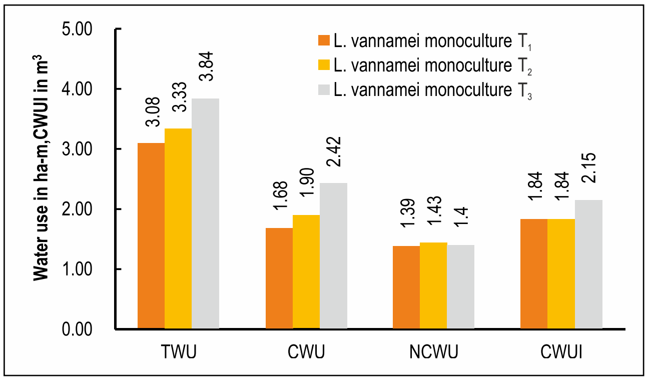
Brahmagiri	17,448	141	Rice/ vegetables	Rice/black gram/ green gram/ groundnut	The area under vegetables may be increased by 10%. Over aged rice seedlings of 60 days age. Bio-drainage with Casuarinas and Eucalyptus sp. *Kharuhan* (Double transplanting) method	The area under green gram and groundnut may be increased by 10%. Spray 2% brine solution to prevent premature germination in field.
Puri Sadar	16,482	160	Rice/ vegetables/ chilli	Black gram/rice/ green gram/ groundnut	The area under vegetables may be increased by 15%. Medium waterlogging tolerant rice varieties like Durga.	The area under green gram and groundnut may be increased by 20%. Crop diversification with sunflower and sesamum in 5% NSA. Raised and sunken bed system.

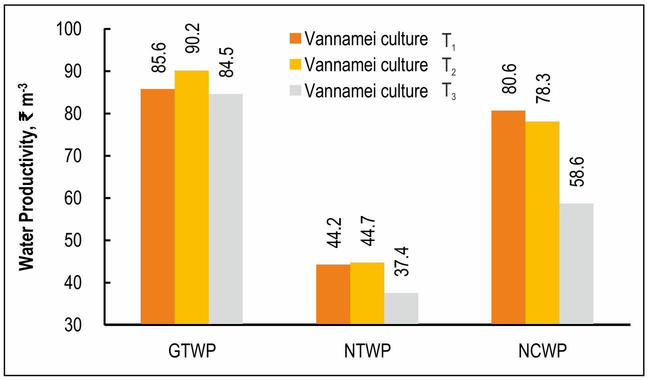
Density-Dependent Water Use in Coastal Aquaculture of *Litopenaeus vannamei*

Project Code : IIWM/15/175

Investigators : R.K. Mohanty, D.K. Panda and P. Panigrahi

An attempt is being made by ICAR-IIWM to quantify the consumptive water use (CWU), total water use (TWU) or total crop water requirement (TWR) and consumptive water use index (CWUI) of commercially important *Litopenaeus vannamei* (Pacific white shrimp) at varying intensity levels to ensure higher water productivity and profitability. During the third crop, there rearing densities were studied for Pacific white shrimp, *Litopenaeus vannamei* [T_1: 0.4 million post larvae (PL) ha^{-1}, T_2: 0.5 million PL ha^{-1}, T_3: 0.6 million PL ha^{-1}] and water cutback approach on rearing environment, water use efficiency, water foot print and production performance. Conditional water exchange was carried out based on water quality parameters. Water quality suitability index was very good (7.5 - 9.0) up to 13th, 10th and 5th week of culture in T_1, T_2 and T_3, respectively; which was attributed to rearing density, smaller-sized shrimp and low early feed input. Optimum rearing density of 50 PL m^{-2} (T_2) led to total water use of 3.33× 10^{4}m^3. It was an effective way to improve shrimp productivity (10.4 t ha^{-1} 120 d^{-1}), consumptive water use index (1.84 m^3 kg^{-1} biomass), total water footprint (1,229 m^3 t^{-1} biomass) and net consumptive water productivity (₹ 78.3 m^{-3}). *L. vannamei* culture with low to moderate water exchange as in T_2, helped uphold water quality suitable for the shrimp growth, improved water use efficiency (0.58 kg biomass m^{-3} water), minimized sediment load (43.5 m^3 t^{-1} biomass), effluent outputs (0.63× 10^4 m^3), pumping cost (₹ 1,957 t^{-1} biomass produced), and ratio of output value to the cost of cultivation (1.97) (Fig. 1). The knowledge resulting from this study could offer the basis to augment shrimp rearing efforts and the water management approaches will help in preventing the production of waste and effluent while increasing water use efficiency and production performance (Fig. 2).





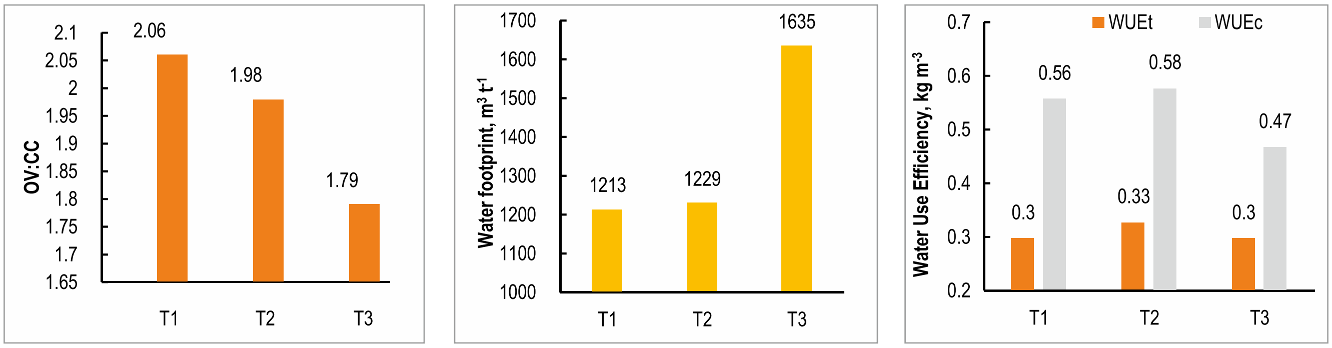


Fig. 1. Treatment-wise water use, water productivity, water footprint, total and consumptive water use efficiency, and ratio of output value to cost of cultivation in monoculture of *L. vannamei*

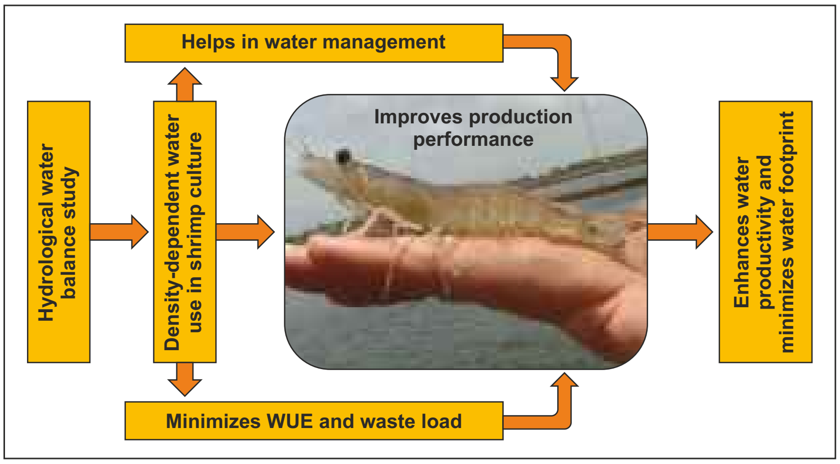


Fig. 2. Graphical abstract of aquacultural water management in monoculture of *L. vannamei*

Water Use Efficient Practices for Successful Establishment and Yield Enhancement of Pulse Crops in Rice Based Cropping System

Project Code : IIWM/16/179

Investigators : P.S. Brahmanand, S. Roy Chowdhury, P. Panigrahi, P. Nanda and S. Raychaudhari

A field experiment was conducted for the second year in the research farm of ICAR-Indian Institute of Water Management, Mendhasal, Bhubaneswar, Odisha to investigate the effect of different water management and nutrient treatments on growth performance of greengram under rice-based cropping system. Split-plot design was adopted with three main-plot treatments of irrigation (M_1: control, i.e. no irrigation; M_2: sprinkler irrigation once at flowering stage; M_3: sprinkler irrigation twice at flowering and pod formation stages) and four sub-plot treatments of N application (S_1: control, no nitrogen; S_2: N at 20 kg ha^{-1} through urea; S_3: N at 20 kg ha^{-1} through urea along with *Rhizobium* inoculation and S_4 : N at 40 kg ha^{-1} through urea) with three replications. In addition, six levels of irrigation (FI: full irrigation, 120% FI, 80% FI, 60% FI, 40% FI, 20% FI and control (no irrigation) were imposed in different growth stages of crop under both surface and sprinkler irrigation to develop water production function in greengram. The initial characteristics of soil were analyzed for second year. The mean soil pH, EC, N, P and K are 4.87, 96 µS cm^{-1}, 188 kg ha^{-1}, 13 kg ha^{-1} and 85 kg ha^{-1} respectively. The analyses of surface soils at harvest showed decreasing trend (M_3>M_2>M_1) in N and K, whereas P content did not show much variation. *Rhizobium* treatment showed healthy nodulation ensuring efficacy of the treatment applied. The number of nodules per plant was 13 to 21. The fresh nodular biomass varied between 119 and 235 mg plant^{-1}. The native rhizobial population was absent in the soil.

In the first year of experimentation i.e. 2017 (*rabi*), the pod yield of greengram was found to be significantly higher (820 kg ha^{-1}) in two stage sprinkler irrigation compared to one stage irrigation and control (Fig. 3). Similarly, the higher pod yield of greengram was recorded with combined application of 20 kg N ha^{-1} supplied through urea and *Rhizobium* inoculation (800 kg ha^{-1}) compared to 20 kg N ha^{-1} supplied through urea alone. Among interaction treatments, two sprinkler irrigations with 20 kg N ha^{-1} supplied through urea and *Rhizobium* inoculation resulted in the highest pod yield of 940 kg ha^{-1}. It was due to higher number of pods per plant, number of seeds per pod and test weight with increment in irrigation and nitrogen. Two irrigations and 20 kg N ha^{-1} through combined application of urea and *Rhizobium* increased pod yield from 0.46 t ha^{-1} to 0.94 t ha^{-1} and net water productivity (from 2.3 to 6.4 ₹ m^{-3}) in greengram.

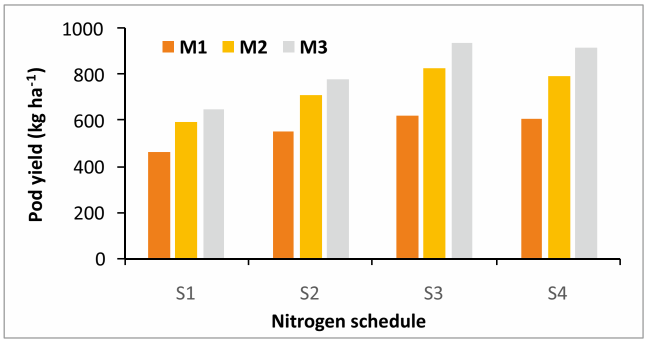


Fig. 3. Pod yield of greengram as influenced by irrigation and nitrogen application

During 2018, crop growth parameters viz., plant height and dry matter accumulation were recorded at 15, 30 and 45 days after sowing (DAS) and crop growth rate was computed for 15-30 and 30-45 DAS. The results revealed that plant height and dry matter accumulation were found on par among the irrigation treatments at 15 and 30 DAS as the irrigation treatment was applied at flowering stage (34 DAS). However, sprinkler irrigation twice (M_3) resulted in significantly greater plant height (27.6 cm) compared to single irrigation (M_2) and no irrigation (M_1) at 45 DAS. Similarly, crop growth was better with N application at 40 kg ha^{-1} applied through urea (S_4) compared to the N @ 20 kg ha^{-1} through urea (S_2) and no nitrogen application (S_1). However, *Rhizobium* inoculation and N application at 20 kg ha^{-1} (S_3) was statistically similar to S_4.

Periodical observation was taken on net photosynthesis rate, stomatal conductance and transpiration at 20, 30, 40 and 45 DAS. The results showed irrigation showed no effect on photosynthesis rate but the N application showed significant variation at 20 DAS itself. Interaction effect between N and irrigation was not significant. However, at 45 DAS N application and irrigation showed significant variation (Table 4). The highest net photosynthesis rate was observed at M_3S_3 and M_3S_4 treatments.

Under different growth stage-based irrigation treatments, irrigation water applied and volumetric soil water content within top 0.6 m soil depth were 26-130 mm and 15.2-24.7%, respectively under sprinkler irrigation. Sprinkler irrigation saved 20-25% water with increasing yield up to 25% compared with that under surface irrigation. The SPAD (21.6-42.4) and PAR (887-1290 μmol m^{-2}s^{-1}) values were higher with irrigation in the crop. Yield was found linearly related (R^2 = 0.89) with the amount of water applied. The yield response factors were found as 0.35, 0.85 and 0.20 in initial, mid-growth and final growth period of the crop, respectively.

Table 4. The effect of both irrigation as well as different N applications on net photosynthesis rate (μmol CO_2 m^{-2} s^{-1}) in greengram grown under different irrigation levels

Treatment	S_1	S_2	S_3	S_4	Mean
M_1	7.73	7.70	8.10	8.20	7.93
M_2	8.97	9.03	10.27	9.30	9.32
M_3	7.93	10.40	13.80	13.07	11.30
Mean	8.21	9.040	10.72	10.19	
LSD (0.05)	M: 1.83; S: 1.69; M×S: 3.12				

Sprinkler irrigation in greengram field

Development and Evaluation of Mini-pan Evaporimeter for On-farm Irrigation Scheduling

Project Code : IIWM/17/183

Investigators : N. Manikandan, P. Panigrahi, S. Pradhan, S.K. Rautaray and G. Kar

An attempt has been made to develop a low cost and easy-to-operate mini-pan evaporimeter for scientific irrigation scheduling at farm level to increase the water and crop productivity. The mini pan evaporimeters were developed using galvanized iron (GI) sheet and PVC pipes with diameters of 10, 20, 30 cm and height 25 cm, and were kept on wooden platform. These mini pan evaporimeters were installed at Agrometeorological Observatory, IIWM Research Farmand evaporation data was recorded on alternate days at 8.30 am.

The evaporation data for about two and half months (January 21- March 31, 2018) revealed that the standard deviation of evaporation from 10 cm mini pan evaporimeter of PVC (5 mm) and GI (4.8 mm) was higher compared to evaporation from USWB open pan evaporimeter (3.4 mm). The least standard deviation was found for 30 cm mini pan evaporimeter of GI (3.4 mm) and PVC (3.7 mm). The evaporation from PVC and GI mini pan evaporimeters with USWB open pan showed that the evaporation from 30 cm GI mini pan had closest relationship (r = 0.95) followed by 30 cm PVC mini pan (r = 0.94). The correlation coefficient was the lowest between USWB open pan evaporation and evaporation from10 cm PVC mini pan (r = 0.82) and 10 cm GI mini pan (r = 0.84) (Figs. 4 and 5). The monthly cumulative evaporation (mm) from USWB pan, GI and PVC mini pan evaporimeters of different diameters during experimental period are presented in Fig. 6.

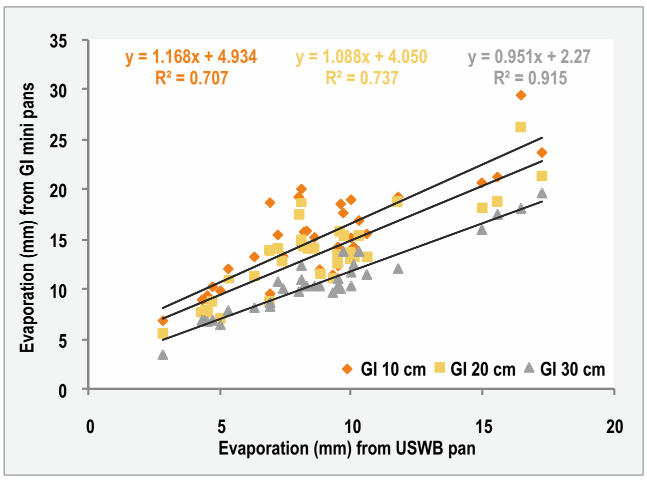


Fig. 4. Scatter plot of evaporation data (n=34) from USWB pan and GI mini-pan evaporimeters

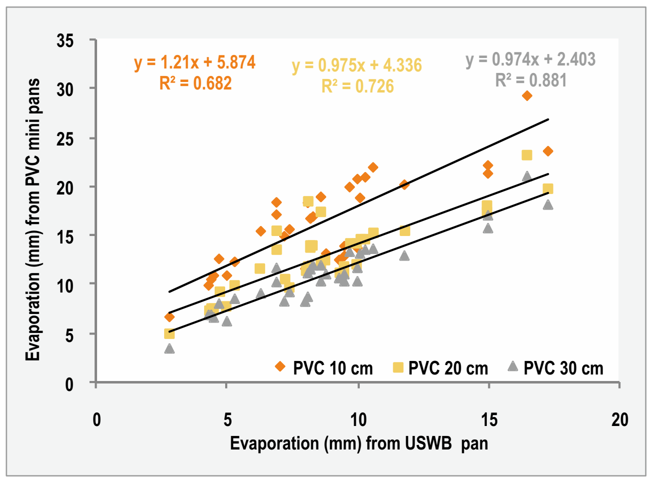


Fig. 5. Scatter plot of evaporation data (n=34) from USWB pan and PVC mini-pan evaporimeters

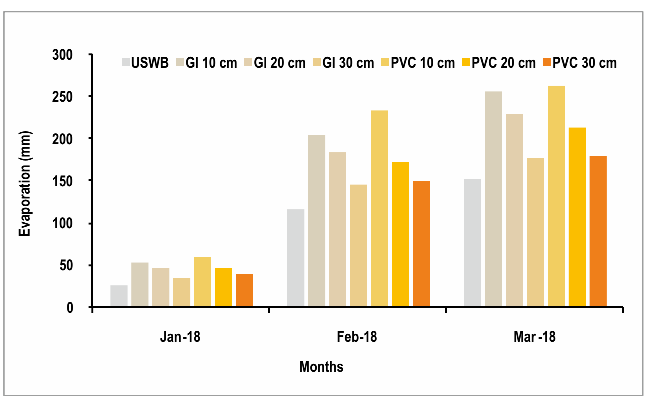


Fig. 6. Comparative monthly cumulative evaporation (mm) from USWB pan,GI and PVC mini-pan evaporimeters of different diameters

Mini-pan evaporimeters (GI and PVC) of different sizes installed research farm

Evaluation of Land Shaping Options for Increasing Farm Income in Coastal Waterlogged Area

Project Code : IIWM/17/184

Investigators : S. Roy Chowdhury, S.K. Rautaray, R.K. Mohanty, N. Manikandan, S. Mohanty and S.K. Ambast

At the start of experiment, for baseline information, socio-economic survey of the farmers was conducted around experimental area at Baghadi and Patna villages in Ersama of Jagatsinghpur district in Odisha. The average land holding of surveyed farmers is 0.77 ha. Average paddy productivity is 1.34 t ha^{-1} due to rainfed lowland waterlogged ecosystem with marginal use of fertilizer and local varieties. Average land holding under paddy cultivation is marginal (0.37 ha) with net return of ₹ 4021 ha^{-1}. In general, chilli, watermelon and seasonal vegetables are grown. The average land holding under such cultivation is 0.13 ha and average net return from vegetable cultivation is ₹ 37540 ha^{-1}. Higher net return is obtained from fresh water aquaculture at ₹ 87083 ha^{-1} pond area with productivity level of 1.44 t ha^{-1}. The average pond size occupied with Indian major carp cultivation is only 0.18 ha. *Litopenaeus vannamei* (Pacific white shrimp) cultivation is a recent trend of intervention and show productivity of 1.34 t ha^{-1}. The shrimp cultivation with *L. vannamei* give the highest net return of ₹ 280417 ha^{-1} from average pond size of 0.3 ha. Backyard poultry is practiced with average holding of 13 birds/batch per household and it give annual net return of ₹ 4530 per household. On an average two cows per house hold are reared which give net return of ₹ 6275 per annum per family in addition to the milk used for family consumption.

The above ground water level reached its peak during month of September 2017 followed by a steady decline in the following months at village Baghadi (Fig. 7). In general above ground water level disappear by the month of December. However, two rains experienced during the month of November (97 mm) and December (82 mm) deferred the drop down of above ground water level in the field. Water level up to 8-11 cm was evident in the two selected sited even in the month of January 2017 (Fig. 7). The pH of the soil profile ranged between 5.31 and 6.60 at 0-15 cm and 45-60 cm depth, respectively during monsoon period (September 20, 2017). However, in post-monsoon period (December 19, 2017), the pH of the soil profile ranged between 5.67 and 6.17 at 0-15 cm and 45-60 cm depth, respectively. The electrical conductivity ($EC_{1:2.5}$) of soil during monsoon period ranged from 0.14 to 0.12 dS m^{-1} at soil depth 0-15, and 45-60 cm soil profile at site 1. However, during post-monsoon period (on 19.12.2017), EC varied between 0.07 and 0.04 at soil depth 0-15, and 45-60 cm soil profile at Baghadi. Similar trend was observed in soils sampled from village Patna during two seasons.

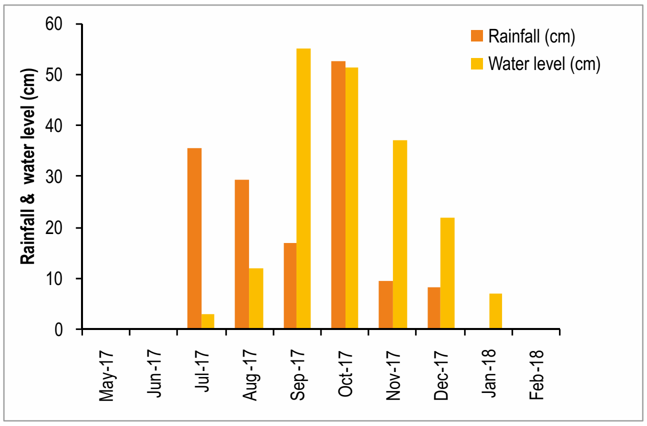


Fig. 7. Rainfall and above-ground water level at experimental site at Baghadi village, Ersama, Jagatsighpur district during 2017-18

Global Yield Gap and Water Productivity Atlas (GYGA)

Collaborative Project : ICAR with University of Nebraska, Lincoln, USA

Investigators : P.S. Brahmanand, N. Subash, S.K. Ambast and A.S. Panwar

This project aims to collect and compile the data on actual yields, yield potential and yield gaps in India to prepare an atlas, for five major crops namely maize, rice, wheat, sorghum and pearl millet. The simulation of potential yields of rice and wheat obtained through The Agricultural Production Systems Simulator (APSIM) was further verified and quality control exercise has been done. Accordingly, the potential yields, actual yields and yield gap trend of different climatic buffer zones were estimated. The yield gap of these two crops was assessed based on the difference between mean actual yields of ten year period from 2001-2011 and potential yield.

The yield gap of rice ranged from 52.6% in Patiala (Punjab) to 83.4% in Patna (Bihar) (Fig. 8). As per the protocol of GYGA, the yield potential of rice of Patiala climatic buffer zone of Punjab was estimated as 8.32 t ha^{-1} using APSIM and its mean actual yield (10 years) was 3.94 t ha^{-1}, hence the yield gap of about 4.38 t ha^{-1} was recorded in this climatic buffer zone which accounts to 52.6% of the potential yield. Similarly, the yield potential of rice at Patna climatic buffer zone of Bihar was estimated as 7.36 t ha^{-1} using APSIM and its mean actual yield (10 years) was 1.22 t ha^{-1}, hence the yield gap of about 6.14 t ha^{-1} was recorded in this climatic buffer zone which accounts for 83.4% of the potential yield.

The yield gap of wheat ranged from 22.5% in Patiala (Punjab) to 68.2% in Palampur (Himachal Pradesh (Fig. 9). The yield potential of wheat of Patiala climatic buffer zone of Punjab was estimated as 5.92 t ha^{-1} using APSIM and its mean actual yield (10 years) was 4.59 t ha^{-1}, hence the yield gap of about 1.33 t ha^{-1} was recorded in this climatic buffer zone which accounts to 22.5% of the potential yield. Similarly, the yield potential of wheat of Palampur climatic buffer zone of Himachal Pradesh was estimated as 4.32 t ha^{-1} using APSIM and its mean actual yield (10 years) was 1.37 t ha^{-1}, hence the yield gap of about 2.95 t ha^{-1} was recorded in this climatic buffer zone which accounts for 68.2% of the potential yield.

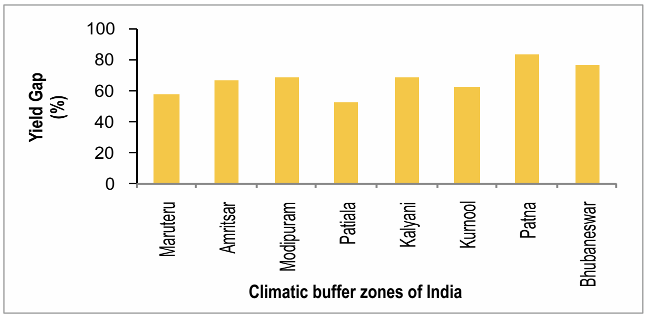


Fig. 8. Yield gap (%) trend of rice in different climatic buffer zones of India

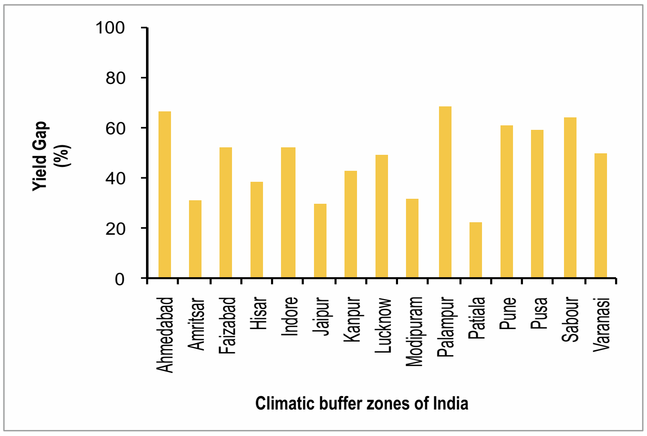


Fig. 9. Yield gap (%) trend of wheat in different climatic buffer zones of India

Index-based Flood Insurance (IBFI) and Post-disaster Management to Promote Agriculture Resilience in Selected States in India

Externally funded project: IWMI, Colombo, Sri Lanka

Investigators : P.S. Brahmanand, S. Roy Chowdhury, S.K. Jena, S.K. Ambast, A.K. Singh, B.P. Bhatt, G. Amarnath and A.K. Sikka

The main objective of this project is to develop index based flood insurance model and to prepare and implement post-flood crop management plan. The project aims to develop multiple research products focusing on integrating remote sensing datasets, flood hazard model for data sensitive locations and crop loss module that can support in upscaling index based flood insurance (IBFI) to other locations. Further to implement and evaluate generated products under IBFI umbrella at developmental scale for multiple crop types in the near future and to create develop a framework for innovative post-flood management activities in conjunction with IBFI to perpetuate agricultural resilience against flood events.

Initial survey was done to assess the crop damage in operational area *i.e.* flood affected areas of Gaighat block, Muzaffarpur district of Bihar. Muzaffarpur district of Bihar comes under Agro-climatic zone no. IV of Middle Gangetic Plain Region. It has about 3,15,000 ha of geographical area and 2,19,000 ha of net sown area with a cropping intensity of 130%. It comprises of 16 blocks namely Musahri, Kurhani, Baruraj (Motipur), Paroo, Minapur, Saraiya, Sakraa, Aurai, Kanti, Gaighat, Bochaha, Katra, Sahebganj, Marwan, Bandra and Dholi (Moraul). It receives an annual rainfall of 1196 mm with 57 rainy days mainly during June-October. Owing to extreme climatic rainfall events, this district is extremely susceptible to floods. The combination of depth (0.4-1.5m) and duration of flood occurrence (8-32 d) poses severe challenge to agricultural sector in this district. Rice and maize are major crops grown during *kharif* season. The crops like rice and maize got severely affected due to flood incidence. Flood water remained in the fields for about 30-45 days and depth varied from 0.3 to 1.4 m. Based on the flood receding trend and on interacting with the farmers, the post-flood management plan has been prepared (Table 5). The farmers have been encouraged to cultivate hybrid maize variety 'Shaktiman-3' and vegetable crops like brinjal, tomato and cauliflower in post-flood situation. Yield loss production function for rice crop is being worked out under different depths and durations of submergence which would be employed for computing flood induced crop damage index.

Table 5. Crop specific post-flood management measures for Muzaffarpur district of Bihar

Crop along with its cultivated area (000' ha)	Scenario	Suggested post-flood management options
Rice (119.3)	a^2&a^4	Double transplanting method (*Kharuhan)* Deep waterlogging resistant varieties like Varshadhan
	a^3	Replanting with *dapog* nursery seedlings Over aged rice seedlings of 60 d duration
	b^3&b^4	Short-duration rice varieties like Prabhat (90 d) Advancing *rabi* maize and potato cultivation in case of complete crop damage
	#	Water chestnut integrated with aquaculture Use copper fungicides against bacterial leaf blight Lentil may be taken up as *paira* crop Establishment of horticultural saplings in rice fields
Maize (13.1)	a^1&a^2	Earthing up Re-sowing and gap-filling
	b^1&c^1	Provision of drainage
	c^3&c^4	Toria / late-sown wheat/ groundnut, if completely damaged
	#	Spray with imidacloprid @ 3ml/10 litre to control stem borer Foliar blight control by Mancozeb @2.5 gl^{-1} or Zineb/Maneb @2.5-4 g l^{-1} of water (2-4 applications at 8-10 d interval)
Potato & other vegetables (10.0)	a^1&a^2	Earthing up Replanting and gap-filling
	b^1&c^1	Provision of drainage
	b^2&b^4	Toria / late-sown wheat, if completely damaged
	#	Grow nursery on raised beds

[a]If flood occurs in early phase (July 1st week to August 1st week); [b]If flood occurs in mid phase (August 2nd week to September 2nd week); [c]If flood occurs in late phase (Sept 3rd week onwards)

[1]Duration of 7 d or less and depth of 0.25-0.5 m; [2]Duration of 7 d or less and depth of 0.5-1m;

[3] Duration of 8-14 d and depth of 0.25-0.5 m; [4]Duration of 8-14 d and depth of 0.5-1 m;

[#]Applicable for all scenario

CANAL WATER MANAGEMENT

Canal Water Management

This program includes research projects on canal water management & related issues

Feasibility Study of Enhancing Irrigation Efficiency through Improved Surface and Pressurized Irrigation Methods with Adjunct Service Reservoir and Open Dug Well

Project Code : IIWM/15/172

Investigators : R.K. Panda, R.R. Sethi, S.K. Rautaray, R.K. Mohanty and P. Panigrahi

Impact of service reservoir and dug-ell on water productivity

Impact of the service reservoir along with the dug-well was studied for the monsoon (*kharif*) and post-monsoon season (*rabi* and summer) during 2017-18. It is evident that due to creation of irrigation infrastructures, crops like paddy in *kharif* and groundnut and green gram in summer seasons could be grown as against of paddy-fallow cropping system prior to the interventions. Paddy crop (var. Lalat) yielded in 3.6 t ha^{-1} with water productivity of 0.29 kg m^{-3} using rainwater and supplemental irrigation water from service reservoir. Introduction of sprinkler irrigation could produce 12.5% higher yield with 40% less water use, resulting in 87% higher water productivity compared with check basin irrigation (yield-1.2 t ha^{-1}; water use-400 mm; water productivity-0.3 kg m^{-3}) in groundnut (var. Smruti).

Economics

The economics of crop production and economic water productivity have been computed and presented in Table 6. The interventions of water resource development and management in crop production and pisciculture enhanced the irrigation intensity by 164% and average annual net income in the target area from ₹ 17,800 ha^{-1} (pre-intervention period) to ₹ 178626 ha^{-1}.

Table 6. Economics of crop production and economic water productivity

Crops	Gross returns (₹ ha^{-1})	Gross Expenditure (₹ ha^{-1})	Net Returns (₹ ha^{-1})	Benefit: cost ratio	Gross water productivity (₹ m^{-3})	Net water productivity (₹ m^{-3})
Rice	54700	42750	11950	1.28	5.24	1.14
Rapeseed	41288	23500	17788	1.76	13.76	5.93
Groundnut	65713	43225	22488	1.52	23.47	8.03
Green gram	36381	26700	9681	1.36	20.21	5.38
Rice-rapeseed-groundnut + pisciculture	368101	189475	178626	1.94	14.95	6.43
Rice-rapeseed-green gram + pisciculture	338769	172950	165819	1.96	14.13	5.76

Inter-Regional Virtual Water Trade in India through Agro-based Products

Project Code : IIWM/15/173

Investigators : G. Kar and P.K. Panda

With changing global climatic patterns coupled with declining per capita availability of surface and ground water resources, sustainable water management in agriculture is a great challenge in India. With increasing water demand from other sectors, agricultural water use in India will face stiff competition for scarce water resources in future. Therefore, available water resources would be inadequate to meet the water needs of all sectors unless the utilizable quantity is increased by all possible means and water is used efficiently. Adoption of suitable agro-techniques for crop cultivation is the need of the hour to produce more crops with less water so as to manage the declining surface and ground water resources in India. Now, priority is the computation of water footprints which indicates the appropriation of fresh water resources from a particular agro-management system.

Recognizing the importance of above facts comparative assessment of water footprints was made under alternative improved crops and crop management practices. Through crop diversification in rainfed upland, water footprints can be reduced significantly. Among crops tried in Dhenkanal, Odisha during kharif season, 2017, lowest water footprint was obtained from maize crop (1100 m^3t^{-1}), whereas from rice it was 2450 m^3t^{-1} (Fig. 10). Micro-irrigation is another option for reduction of water footprints in agriculture. Through dug-well based drip irrigation system in hard rock areas of Dhenkanal,, 51.5, 63.8 and 63.9% water footprints were reduced when drip was applied at 80% ETc to cauliflower, potato and chili, respectively than that of surface irrigation system (1.0 IW/CPE) (Fig. 11).

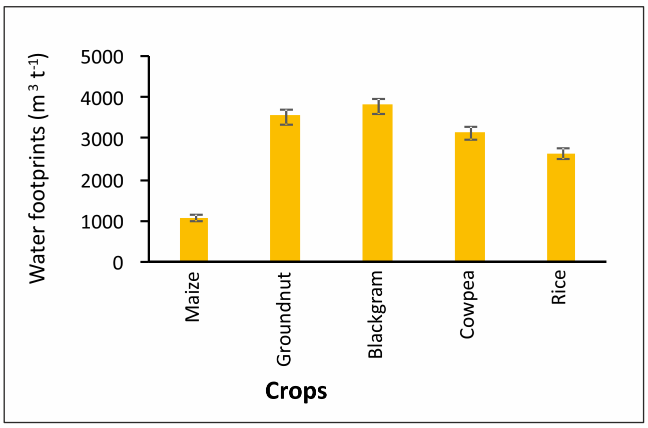


Fig. 10. Water footprints in diversified crops in rainfed upland in Dhenkanal, Odisha

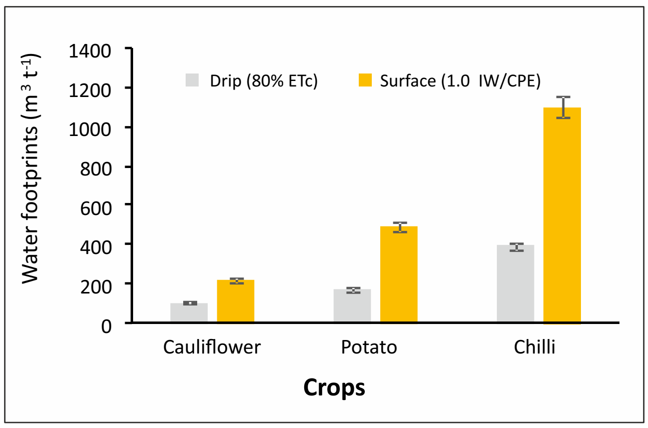


Fig. 11. Water footprints of vegetable crops under drip and surface irrigation in Dhenkanal, Odisha

Impact of climate change on water footprints in rice

Global mean surface temperatures for 2081–2100 relative to 1986–2005 is likely to increase by 0.3-1.7 °C, 1.1-2.6 °C, 1.4-3.1°C and 2.6-4.8°C under RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5, respectively. Under RCP 8.5 scenario, impact of elevated temperature on virtual water footprints (m^3t^{-1}) of Punjab, Odisha and Tamil Nadu revealed that water footprints of rice is likely to increase by 2.5, 4.3-7.1 and 9.4-11.3% in 2050, 2070 and 2090, respectively (Figs.12a, b & c). Among the 3 states, higher water footprint was obtained in Odisha than that of Punjab and Tamil Nadu.

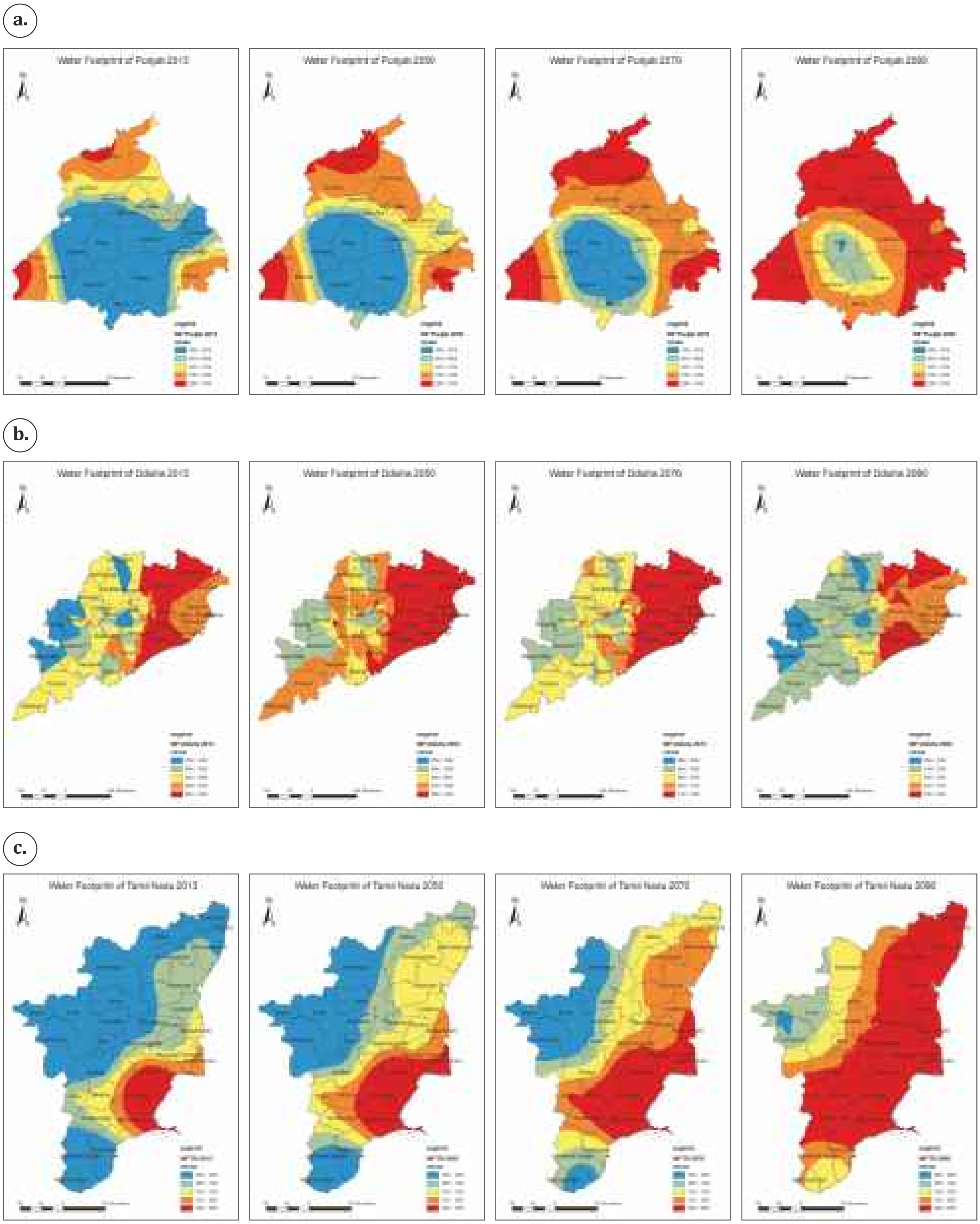


Fig. 12. Present and future water footprint scenario of rice in (a) Punjab, (b) Odisha and (c) Tamil Nadu

Enhancing Water Productivity through Water Management in Transplanted and Aerobic Rice in Canal Command Area

Project Code : IIWM/15/174

Investigators : K.G. Mandal, A.K. Thakur, R.R. Sethi, M. Raychaudhuri and R.K. Panda

Rice is the staple food for half of the world's population, and rice farming is the livelihood for millions of farmers in India and Asian countries. It provides an individual in India with an average of 32% of the total calorie and 24% of total protein intake per day. Water or irrigation input to rice farming is typically very high, and of course, it depends upon growing season, climatic conditions, soil type and hydrological conditions. Reducing water requirement of this crop and enhancing water productivity is a challenge. Therefore, field experiments were conducted on rice during *rabi*/ summer season 2016-17 and *kharif* season 2017 at the institute research farm to study the effects of various water management techniques on transplanted and direct seeded rice with the aim to enhance water productivity of this crop.

A rice variety, 'Khandagiri' (OR 811-2) of 95 days duration having high potential yield of 6.0 t ha^{-1} was grown during *kharif* and *rabi*/ summer seasons. Direct wet-seeding and puddled transplanting treatments were imposed during both the seasons, whereas alternate wetting and drying (AWD), and irrigation at 3-days after disappearance (3-DAD) of water were compared with continuous flooding (CF) during *rabi*/ summer season. In every treatment, crop was grown with recommended rate of N, P_2O_5& K_2O at 80, 40 & 40 kg ha^{-1}. Farmyard manure was applied once before final ploughing and puddling during *kharif* season. Pre-germinated seeds were used for direct wet-seeding and nursery raising on the same day. Transplanting was carried out on the puddled soil with 18-21 day's old seedlings. Standard practices were carried for manual weeding and plant protection measures against insect-pests and diseases. Crop physiological and yield parameters were determined for the crop receiving different treatment combinations.

Experimental findings show that the performance of rice was similar with direct wet-seeding and puddled transplanting during *kharif* as well as *rabi*/ summer seasons. Grain yield ranged from 4.26 to 4.32 t ha^{-1} in direct wet-seeding and transplanting treatments. This implies that direct wet-seeding would be a viable practice for rice growers in the region. Alternate wetting and drying (AWD), and irrigation at 3-days after disappearance (3-DAD) of water were compared with continuous flooding (CF) during *rabi*/ summer season. Grain yield was statistically similar in all irrigation

Rice grown with different treatments viz. a) CF: continuous flooding, b) 3-DAD: irrigation at 3 days after disappearance of water, and c) AWD: alternate wetting and drying

treatments viz. CF, 3-DAD and AWD (Fig. 13); water saving was about 22% in 3-DAD and 28% in AWD compared to CF. Consequently, water productivity increased by 27 and 38% in 3-DAD and AWD, respectively over CF (Fig. 14). Further, water balance parameters were monitored through drum culture techniques; and it was estimated that the average percolation, evaporation and transpiration rate was as 1.01, 3.45 and 4.41 mm d^{-1}, respectively from the puddled transplanted field during the crop growing period in *rabi*/ summer season. Higher yield was attributed to better crop growth and physiology i.e. better LAI (2.54 to 2.88), SPAD chlorophyll meter reading (35.5-43.3) and interception of PAR (62-78%), yield components viz. number of spikelet per panicle in CF, 3-DAD and AWD under direct-seeded or transplanted conditions. Nutrient contents were analyzed for grains and straw obtained from imposed treatments during *rabi*/ summer season (2016-17) and nutrient status was also monitored for post-harvest soils. In general, grain and straw-N, P & K contents did not vary significantly due to treatments; post-harvest soil was slightly acidic; available- N, P and K was found low to medium. Hence, direct-seeding of rice and two methods viz. alternate wetting and drying and irrigation at 3-days after disappearance hold promise with significant saving of irrigation for rice farming in the region.

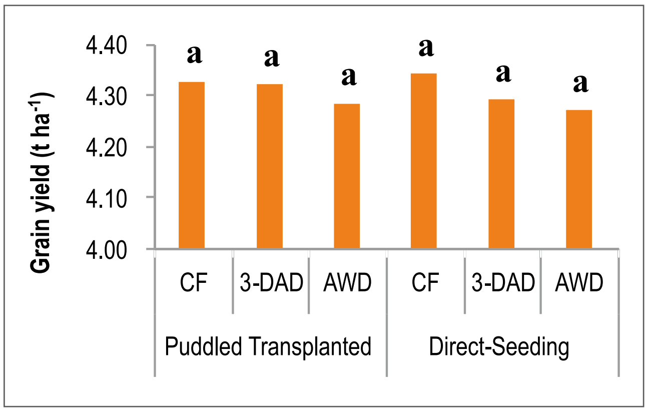


Fig. 13. Grain yield (t ha^{-1}) of rice (var. 'Khandagiri') with different water management treatments under puddled transplanted and wet direct-seeding conditions during *rabi* / summer season

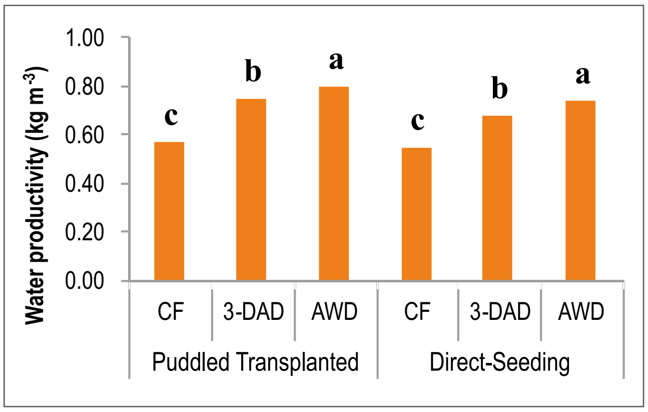


Fig. 14. Water productivity (kg m^{-3}) of rice (var. 'Khandagiri') with different water management treatments under puddled transplanted and wet direct-seeding conditions during *rabi*/ summer season

CF: continuous flooding, 3-DAD: irrigation at 3 days after disappearance of water, AWD: alternate wetting and drying; different letters above bars indicate significant difference at $p < 0.05$ according to Duncan's multiple range test.

Benchmarking of Public Irrigation Schemes for Improving Performance of Irrigated Agriculture

Project Code : IIWM/16/177

Investigators : A. Mishra, A.K. Nayak, D.K. Panda, P. Nanda and S.K. Ambast

In the year under report, water auditing data of Maharashtra state was analyzed. About 65 major and 227 medium projects of five different plan groups (highly deficit, deficit, normal, surplus and abundant) for last five years (2007-08 to 2011-12) have been considered for data collection for water auditing. Water auditing analysis was carried out with a set of indicators.

Water availability in reservoirs on 15th October

This indicator gives percentage of design live storage available on the on-set of Rabi season i.e. on 15th October. Table 7 presents the number of major and medium irrigation projects with certain percentage of storage. Maximum number of projects both major and medium systems have storage of 80-100% of the design live storage on the onset of *rabi* season i.e., 15th of October. Only few irrigation projects are observed to have storage below 50% on 15th of October.

Table 7. Number of irrigation projects with specific percentage of storage on 15th October

Sl. No.	Storage (%)	Number of major irrigation project						Number of medium irrigation project					
		2007-08	2008-09	2009-10	2010-11	2011-12	Av.	2007-08	2008-09	2009-10	2010-11	2011-12	Av.
1	>100	3	2	1	1	2	2	2	2	2	2	1	1
2	80 – 100	14	10	5	8	7	9	21	10	11	33	29	21
3	50 – 80	1	4	2	5	1	3	4	4	5	5	2	4
4	< 50	-	-	3	1	2	1	2	3	6	5	6	4

Water availability percentage for different plan groups of major irrigation projects (Fig. 15) and medium irrigation projects (Fig. 16) has been depicted. In case of highly deficit at the beginning of *rabi* season, the reservoir is observed to be full. In case of deficit, normal and abundant plan groups of major irrigation system, the average percentage of water availability is found to be 76.8, 93.5 and 89.2 %, respectively. Thus, the deficit plan group of systems has lowest percentage of water availability. No definite trend is observed for amongst type of irrigation system. The average percentage of water availability on 15th October are found to be 83, 83.29, 88.46, 70.43 and 94.54 % for highly deficit, deficit, normal, surplus and abundant type of medium irrigation projects respectively. Thus, in case of medium irrigation projects, the lowest water availability is observed in surplus plan group.

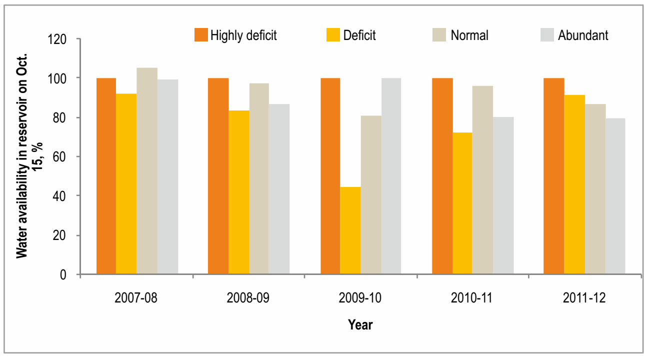


Fig. 15. Water availability in the reservoir as percentage of design live storage in major irrigation projects

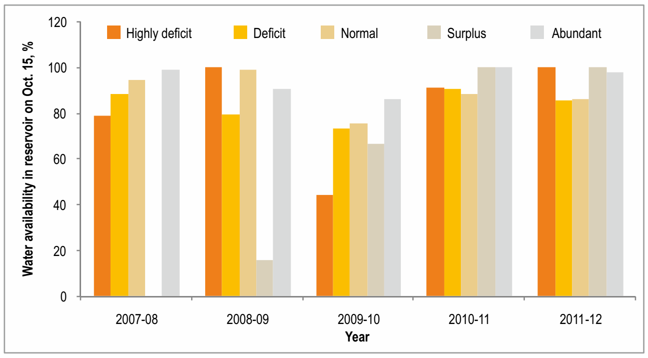


Fig. 16. Water availability in the reservoir as percentage of design live storage in medium irrigation projects

Year-wise average percentage of water availability for both major and medium irrigation projects showed that in almost all the years baring 2010-11, the percentage of water availability in major irrigation systems is found to be more than medium irrigation systems. Year 2009-10 is observed to be the worst year having average water availability percentage as 76.13% and 71.7 % for major and medium irrigation projects, respectively.

The other indicators which were used for further analysis of water audit data are: Percentage of actual evaporation to live storage on 15th October, target and actual irrigation potential utilization, water use pattern, irrigation system performance, ratio between planned and actual non-irrigation uses, ratio between unutilized water and live storage on 15th October, conveyance efficiency of main canals, and actual cropping pattern. The development of a user friendly software in Visual Basic programming language is in progress for analysis of benchmarking data.

Enhancing Yield and Water Productivity in Rice Fallows of Eastern India through Super Absorbent Polymers (SAP)

Project Code : IIWM/16/182

Investigators : S. Pradhan, O.P. Verma, A.K. Thakur and S.K. Ambast

A field experiment was conducted during the *rabi* season at the ICAR-IIWM research farm to evaluate the effect of super absorbent polymer (SAP) on growth, yield and water productivity of groundnut (cv. 'Smruti'). The treatments viz. rate of SAP application was 100, 75, 50, 25 kg ha^{-1} and those were compared with control i.e. no application (C), accordingly treatment symbols were used. Treatments were laid out in randomized complete block design with four replications. The groundnut was grown in a plot size of 5 × 4 m with a spacing of 30 × 20 cm. The result showed that groundnut pods/pant varied from 11 (SAP25) to 14 (SAP50), kernel weight from 1039 (SAP25) to 1174 kg ha^{-1} (C), shell weight 608 (SAP75) to 703 kg ha^{-1} (SAP100), pod weight 1647 (SAP25) to 1864 kg ha^{-1} (SAP100), shelling percentage 60 (SAP25) to 65 (SAP75 and C), haulm yield 2768 (SAP75) to 3220 kg ha^{-1} (C). Yield and yield attributes of groundnut crop were not significantly (P<0.05) affected by the SAP treatments and no variation in water use and water productivity among treatments were recorded (Table 8).

Table 8. Yield and yield parameters of groundnut crop grown under different SAP levels

Treatment	Pods/ plant	Kernal weight (kg ha^{-1})	Shell weight (kg ha^{-1})	Pod weight (kg ha^{-1})	Shelling (%)	Haulm yield (kg ha^{-1})	Water used (mm)	Water productivity (kg m^{-3})
Control (SAP0)	13	1174	619	1793	65	3220	286	0.41
SAP25	11	1039	609	1647	63	3078	284	0.37
SAP50	14	1043	701	1744	60	3093	283	0.37
SAP75	13	1150	608	1758	65	2768	283	0.41
SAP100	12	1162	703	1864	62	3040	282	0.41
CD(P=0.05)	ns	ns	ns	ns	ns	ns	-	-

After groundnut, rice crop (var. Lalat) was grown on the same plot. At flowering stage of rice, LAI varied from 3.84 (SAP75) to 4.02 (SAP100), greenness index as measured by SPAD from 37 (C) to 40 (SAP75), intercepted PAR from 96% (SAP100) to 98% (SAP25 and SAP50) and were not significantly (P<0.05) affected by the SAP levels. The mean residual soil moisture after rice harvest was 0.27 cm^{3}cm^{-3} and 0.26 cm^{3}cm^{-3} for 0-15 and 15-30 cm soil layers, respectively which were close to the field capacity (0.28 cm^{3}cm^{-3}). The rice grain yield were also not significantly (P<0.05) affected under different levels of SAP application (Fig. 17). The water productivity of rice showed 4% variation among the SAP treatments, 0.46 kgm^{-3} was the lowest in control and 0.48 kgm^{-3} was the highest in SAP100.

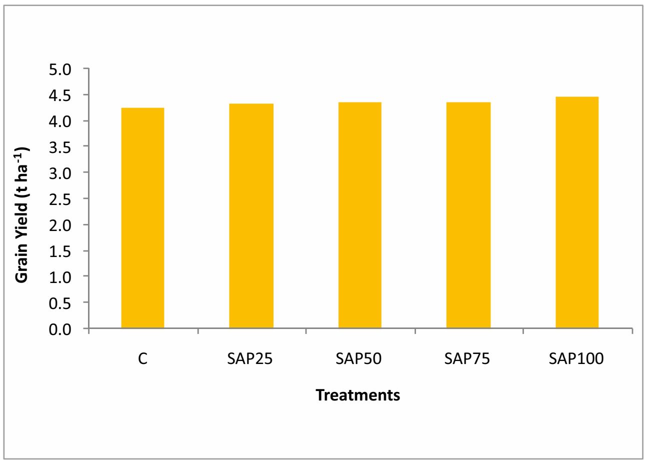


Fig. 17. Rice grain yield under treatments of different SAP levels

Rice crop growth in control (left) and SAP100 treatment (right)

National Innovations for Climate Resilient Agriculture (NICRA)

Externally funded project : NICRA, ICAR, New Delhi

Investigators : G. Kar, S. Mohanty, P.S.B. Anand, D.K. Panda and A. Raviraj

CO_2 sequestration, gross primary productivity (GPP) and net ecosystem exchange (NEE) in rice-based cropping system

Gross primary productivity, ecosystem respiration, net ecosystem exchange in relation with phenology and leaf area index over rice was studied during *kharif* season 2017using eddy covariance technique. It revealed that rice crop was the net sink of CO_2 from tillering to milk stage; the seasonal NEE at the end of growing period was recorded as -308 g C m^{-2}. The daily variation of NEE revealed that maximum net ecosystem exchange was -21 µmole $m^{-2}s^{-1}$ at 11:30 hr and it was highly influenced by leaf area index (LAI) (Fig. 18). It showed a day-time uptake (negative NEE, i.e. uptake of CO_2 due to photosynthetic assimilation) and night-time release of CO_2 (positive NEE, i.e. emission of CO_2 due to respiration in absence of photosynthesis) from the canopy. Diurnal NEE reached its maximum during panicle initiation to booting stage and the value ranged between about 12-16 µmole $m^{-2}s^{-1}$ during the period (Fig. 19).

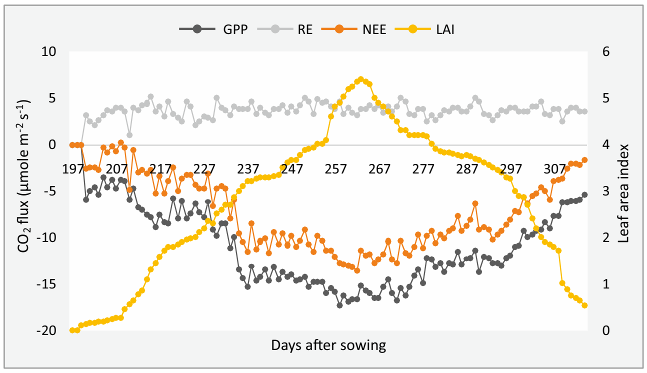


Fig. 18. Seasonal variation of gross primary productivity (GPP), ecosystem respiration (RE), net ecosystem exchange (NEE) and leaf area index (LAI) of rice

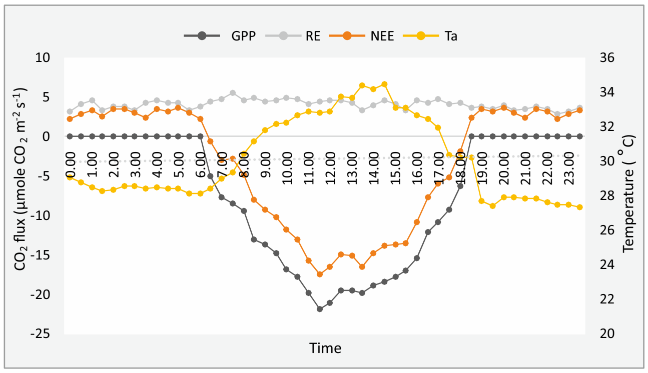


Fig. 19. Diurnal variation of gross primary productivity (GPP), ecosystem respiration (RE), net ecosystem exchange (NEE) and average temperature (Ta)

Fertigation in vegetable crops to develop climate resilient agriculture

To improve the water and nutrient use efficiency under drip and surface, on-farm experiments on drip-fertigation were continued on cowpea and okra during 2017-18. The treatment in each crop included T_1: surface irrigation + 100% recommended dose of fertilizer (soil application), T_2: drip + 100% RDF (soil application); T_3: drip + 100% RDF (fertigation); T_4: drip + 80% RDF (fertigation); T5: drip + 60% RDF (fertigation). The design was RBD with 3 replications. The irrigation was applied through drip under 80% ETc along with soluble fertilizer (19:19:19 N, P_2O_5, K_2O) at different doses. Study revealed that drip + 100% RDF through fertigation (T3) was the best to improve the yield but statistically at par with the treatment of Drip + 80% RFD fertigation (T4) (Table 9). Under drip with 100% RDF (fertigation) crop productivity enhanced by 53.6% in okra and 68.9% in cowpea compared to surface irrigation with 100% RDF (soil application).

Table 9. Crop productivity (tha^{-1}) of vegetable crops under drip-fertigation and soil application of fertilizers

Treatments	Okra		Cowpea	
	Fruit yield (t ha^{-1})	Yield (%) increase over T_1	Pod yield (t ha^{-1})	Yield (%) increase over T_1
T1: Surface irrigation + 100% RDF (soil application)	6.9	-	2.9	-
T2: Drip + 100% RDF (soil application)	9.6	39.1	3.6	24.1

T3: Drip + 100% RDF (fertigation)	11.6	53.6	4.9	68.9
T4: Drip + 80% RDF (fertigation)	10.9	43.4	4.7	62.1
T5: Drip + 60% RDF (fertigation)	7.5	23.1	3.7	8.3
LSD (P=0.05)	1.93	-	1.4	-

Water harvesting and on-dyke agro-forestry to mitigate waterlogged and flood prone areas

Coastal waterlogged areas are subjected to receive both extreme events. The suitable structure was designed in farmers' field to create micro-water resources in seasonal waterlogging area. Waterlogging tolerant rice varieties (cv. 'Hangseswari' and 'Sabita') were grown in adjoining areas to the dyke of the structure during *kharif* season. The dyke was utilized to grow forestry species like *Acacia auriculiformis*, Casuarina *etc.* The harvested water inside the structure was utilized for fish rearing, also to grow second crops (rice, vegetables) surrounding the structure by providing supplemental irrigation from harvested water. Net return of ₹ 71811-98032 $ha^{-1}annum^{-1}$ with B: C ratio of 3.0 was obtained after intervention. About 50 farmers of Satyabadi and Kanas blocks of Puri district have adopted the technology in about 40 ha of land.

Impact of rainfall variability on groundwater quality

Groundwater pollution due to release of untreated waste water into the water ways and lands from textile and dyeing units located in Coimbatore district contaminated the groundwater over the 40 years period. It fluctuates according to rainfall, water level of wells. Thus, impact of rainfall variability on groundwater quality was studied in Coimbatore and increase in TDS and NO_3 was observed in the groundwater in rainfall deficit years. In deficit rainfall years, increase in TDS was more than 1100 mg L^{-1}. The NO_3 level in the groundwater was > 14 mg L^{-1} but value was within the permissible limit (50 mg L^{-1}). Mainly, agricultural pollution and indiscriminate use of N-fertilizers are the reason for NO_3 pollution in the region.

Development of conjunctive use strategy under changing climate scenarios in Brahmani River basin

Monthly groundwater monitoring was carried out in 16 open dug wells spread across the watershed. In the month of May, the groundwater level varied from 2.83 m to 12.97 m below ground level across the study area. The groundwater level varied from 0.47 m to 8.19 m below ground surface in August, whereas in November it was 0.62 m to 7.92 m below ground surface. Daily gauging of runoff in the flow period was done at the weir structure at Giridhariprasad site. Highest average daily discharge of 3.83 $m^3 s^{-1}$ was observed in the month of September and the flow continued up to mid-January. The gauging structure runoff data along with the rainfall data is shown Fig. 20.

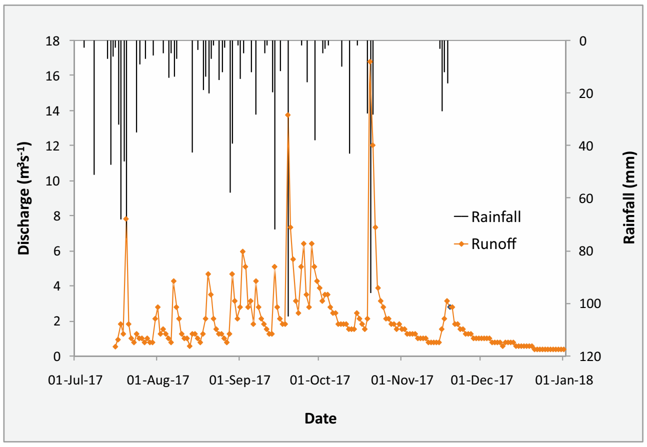


Fig. 20. Variation of daily discharge at the gauging site

The SRTM data of the study area was downloaded and the digital elevation map was prepared using Arc-GIS software. The soil map and land use map of the study area were prepared using NBSS&LUP soil series map and NRSC land use map. Model set up for the study area was done using the ArcSWAT software. Delineation of the watershed into sub-watersheds which using DEM and drainage network data was superimposed on the drainage map.

The model was run for two year (2016 and 2017) for calibration using the SWAT-CUP software. The values of mean error (ME), mean absolute error (MAE), Nash-Sutcliffe Efficiency (NSE) and R^2 were 0.58 $m^3 s^{-1}$, 0.71 $m^3 s^{-1}$, 0.57 and 0.74, respectively. From the calibrated model, zone-wise daily groundwater recharge was estimated. The groundwater recharge in the year 2016 and 2017 were estimated as 211 mm and 261 mm, respectively.

Enhancing Economic Water Productivity in Irrigation Canal Commands

Externally funded project: IWMI, Colombo, Sri Lanka

Investigators : R.K. Panda, S.K. Ambast, S.D. Gorantiwar, S. Bodake, S.A. Kadam, U. Amarasinghe and A.K. Sikka

A collaborating research project was taken up jointly between International Water Management Institute (IWMI), ICAR-Indian Institute of Water Management and AICRP-IWM, Rahuri (Maharashtra) with an objective to identify the physical and institutional interventions for increasing the economic water productivity sustainably in canal command area through development of a Systematic Asset Management (SAM) tool. Sina medium irrigation command of Maharashtra was selected for this study. The Sina medium irrigation project in a semi-arid region of Maharashtra State is located on river Sina in district Ahmednagar. The total catchment of river Sina is 11924 km^2. Through benchmarking of the canal system for the period 2001-2011 revealed that for some of the indicators, the Sina canal system is over performing and for some of the indicators, it is under performing with reference to the state norm reported during 2009 (Table 10). Similarly, using remote sensing and GIS, the influence of cropping pattern in a buffer zone of 1 km outside, it is evident that there is a substantial cropping outside the command area (Fig. 21).

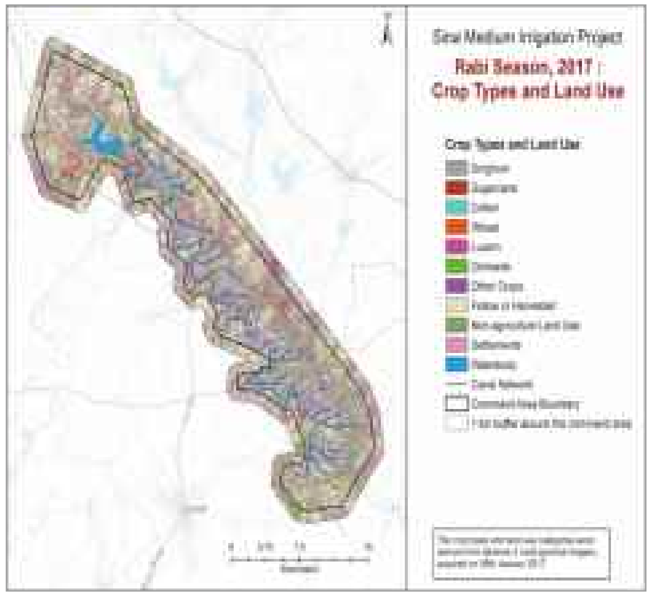


Fig. 21. Remote sensing /GIS analysis within and 1 km outside the command area

Table 10. Benchmarking of Sina medium irrigation system (2001-2011)

Domain	Indicators	Particulars for Sina MIP	State target values as for 2009 *
System Performance	Irrigation water supply per unit irrigated area (Total water supplied per ha) (m^3 ha^{-1})	8961	7692
	Potential Utilized & Created (Area utilized per unit area created)	0.67	1.0
Agricultural Productivity	Output per unit irrigated area (Agricultural production per unit irrigated area) (₹ ha^{-1})	22576	24000
	Output per unit irrigation water supply (Agricultural production per actual water supplied) (₹ m^{-3})	4.73	3.0
Financial aspects	Cost Recovery ratio (Water charges per administrative cost of providing the service)	0.05	1.0
	Total O & M cost per unit area (Total O & M of system per area irrigated) (₹ ha^{-1})	4031	1200
	O & M cost per unit total water supply (Total O & M of system per area irrigated) (₹ m^{-3})	0.71	0.16
	Revenue per unit of total water use (₹ m^{-3})	0.03	0.18

**Report on Benchmarking of irrigation projects in Maharashtra state (March 2009), Water Resources Department, Govt. of Maharashtra, pp. 197.*

Groundwater Management

This program includes research projects on groundwater management & related issues

Enhancing Water Productivity through Intensive Horticultural System in Degraded Land

Project Code : IIWM/15/176

Investigators : S. Pradhan, Prativa Sahu, K.G. Mandal and P. Panigrahi

Field study was conducted to evaluate the performance of pre-bearing mango plants (cv. Amrapali) with different intercrops (papaya, pineapple and combination of papaya and pineapple) under drip irrigation at ICAR-IIWM, Bhubaneswar. Two rows of papaya (cv. Red lady) in either side of mango plants, two paired rows of pineapple (cv. Queen) in either side of mango plants and, one row of papaya and one paired row of pineapple in either side of mango plants using on-line and in-line drip irrigation systems were grown. Soil sampling was done from the experimental field to determine the physical and chemical properties. The texture of soil is sandy loam with bulk density of 1.5 g cm^{-3} and soil pH of 5.7. The organic carbon content of soil was 0.7%. The mean soil available N and K in the surface soil (0-15 cm) in different crops were 285 kg ha^{-1} and 262 kg ha^{-1}, respectively. Fertilizers application and other management practices were done following the recommendations for the crops in the region.

Papaya and pineapple intercropped with pre-bearing mango under drip irrigation

The hydraulic study of drip irrigation in field was found satisfactory with emitter flow rate variation (Q_v) of 5%, co-efficient of variation (CV) of 4% and distribution uniformity (DU) of 95%. Water used, growth, yield and water productivity of the plants is given in Table 11. Irrigation was done in daily basis during April-June and November-March of the study period, as per the water requirement of the crops in the region. Water applied in mango, papaya and pineapple were 650 mm, 570 mm and 325 mm, respectively, under drip irrigation. The volumetric soil water content in top 0.60 m soil in mango, papaya and pineapple were 20-23%, 21-24% and 22-24%, respectively. The vegetative growth parameters viz. plant height, canopy diameter and trunk girth of the mango plants were not affected significantly either by papaya and/ pineapple intercrops. The highest yield or pine apple equivalent yield (17.48 t ha^{-1}) with highest water productivity (21.11 kg ha-mm^{-1}) was observed in mango intercropped with pineapple under straw mulch. Overall, the study reveals that mango intercropped with pineapple under rice straw mulch and drip irrigation can be practiced in pre-bearing mango orchards of the study region.

Table 11. Vegetative growth, water use and yield of plants under different treatments

Treatments	Mango			Papaya			Pineapple			Water used (mm)	Yield / PEY (t ha^{-1})	WP (kg ha-mm^{-1})
	Plant height (m)	Canopy diameter (m)	Trunk girth (cm)	Herb height (m)	Canopy diameter (m)	Fruit set (No.)	Shrub height (cm)	No. of leaves	No. of suckers slips^{-1}			
Mango+ Papaya+ Pineapple	2.50	2.37	26.2	1.34	11.24	7.27	31.6	30	4	1545	11.24	7.27
Mango+ Pineapple	2.67	2.85	28.4	-	17.14	17.58	34.8	33	5	975	17.14	17.58
Mango+ papaya	2.52	2..48	28.0	1.42	5.34	4.38	-	-	-	1220	5.34	4.38
Mango+ Papaya+ Pineapple+ Straw mulch	2.64	2.54	27.4	1.46	11.37	8.36	33.5	32	5	1360	11.37	8.36
Mango+ Pineapple+ Straw mulch	2.80	3.01	28.8	-	17.48	21.11	34.8	35	6	828	17.48	21.11
Mango+ papaya + Straw mulch	2.72	2.66	28.5	1.47	5.43	5.05	-	-	-	1075	5.43	5.05
Mango + Straw Mulch	3.06	3.25	29.3	-	-	-	-	-	-	572	-	-
Mango	2.92	3.14	29.0	-	-	-	-	-	-	650	-	-
CD (p=0.05)	ns	ns	ns	ns	1.08	0.86	ns	ns	ns	----	1.08	0.86

PEY: Pineapple equivalent yield, WP: Water productivity

Socioeconomic and Environmental Linkages of Groundwater Irrigation in Coastal Aquifers of Eastern India

Project Code : IIWM/16/178

Investigators : D.K. Panda, S. Mohanty, M. Das and O.P. Verma

Two intensely groundwater irrigated districts are East and West Godavari in Andhra Pradesh. These districts area drained by the Godavari River basin. Rice is grown in 0.33 million ha in these two districts with the productivity of 4.6 t ha^{-1} during the dry season, leading to decline in groundwater level, particularly severe in West Godavari. A total of 69 piezometric water table records during January 2010 to December 2016 indicates a decline of 0.35 m $year^{-1}$ in the West Godavari district, as water tables have not recovered to the wet season amplitudes since 2014 (Fig. 22). Some specific locations in the alluvial aquifer, groundwater level is seen to be declining monotonically, thus not depicting the natural seasonal cycle of subsurface hydrology. Interestingly, we find the area under *rabi* rice cultivation reduces drastically following a deficient monsoon rainfall, corroborated by the vegetation index (i.e., NDVI) with a linear relationship of 0.48.

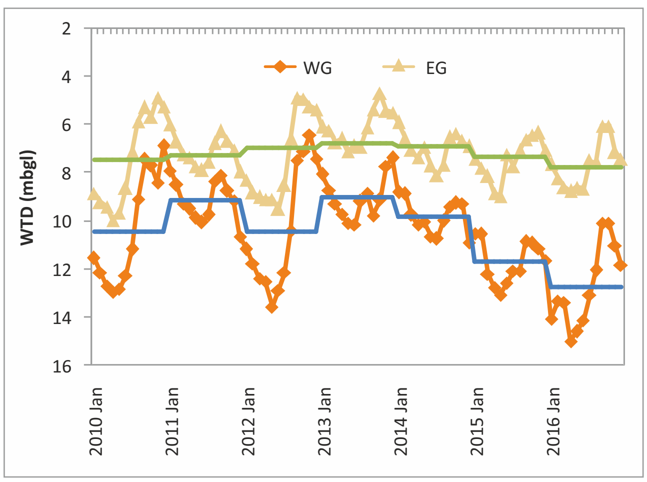


Fig. 22. The average monthly water table depths (meter below ground level, mbgl) in East (EG) and West Godavari (WG) districts during January 2010 to December 2016

Quantile regression of seasonal rainfall during 1981-2015 indicates that the rainfall during October to December, driven by north-east monsoon wind and that lessen the dependence on groundwater, shows declines in both the 25th and 50th quartiles since 1999, while decreasing trend is observed in the 50th and 75th quartiles of the monsoon rainfall. Despite moisture stress from rainfall, the significant increases in vegetation points to the dependence on groundwater in the dry season with the average NDVI rising 0.22×10^{-2} $year^{-1}$ with about 7% increase since 1995. It is note that this is against the backdrop that the rising pre-monsoon evaporative demands of atmosphere, with the average potential evaporation, double of the corresponding rainfall, increasing 0.38 mm per year (Fig. 23). Water, other than from rainfall, appears to have met these atmospheric demands for crop growth, as the ratio of evaporation to potential evaporation, termed as evaporative stress, is also increasing simultaneously. This provides indirect evidence regarding the sustained stress on aquifer.

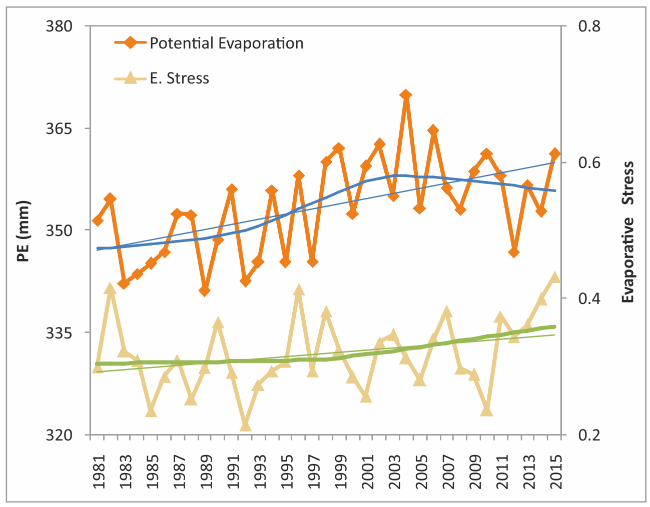


Fig. 23. The pre-monsoon season potential evaporation (PE) and evaporative stress averaged over East (EG) and West Godavari (WG) districts during 1981-2015

In order to understand how the social and political drivers acted to meet the increased water demands, a total of 100 farmers were surveyed. Farmers generally drill up to an average depth of 45-55 m, while a distance of 200 meters should be between wells as prescribed by the Government. Following flooded irrigation method, a bore-well generally irrigates more than 2 ha of the dry season paddy, with the average yield of about 6 t ha^{-1}, compared to the monsoon season yield of 4 t ha^{-1}. A net profit of about 10 to 12 thousand rupees has been estimated per acre from the summer rice. Still what facilitated the expansion of groundwater irrigation is the Government's policy to provide free electricity with a nominal charge of ₹ 250 in 6 months and supplying daily 7 hours of electricity for pumping water. Additionally, a subsidy of 1 lakh for transformer to a group of three farmers has helped to dig more bore wells. Therefore, water market does not exist in the Godavari basin, contrasting other eastern basin aquifers. Restriction was there earlier in the 1980s with the charge of ₹ 50 month^{-1} HP^{-1}.

In the coastal part, where groundwater is highly saline, not suitable for agriculture and portable purposes, commercial aquaculture is flourishing fast, thus takes advantage of the Government policy.

Design and Field Evaluation of Groundwater Recharge Structures in Hard Rock Areas

Project Code : IIWM/16/180

Investigators : Ranu Rani Sethi, M. Das, B. Panda and S.K. Ambast

Study was conducted in Bargharianala micro watershed, Nachipur Gram Panchayat, Daspalla block in Nayagarh district of Odisha. Potential areas for groundwater recharge was delineated by using multi criteria analysis i.e. land use land cover, contour, drainage pattern, slope, soil and hydro-geological map by using ARC GIS 10 software. Very high potential areas for recharge were delineated as 111 ha within the watershed (Fig.24). Two villages were identified in Srirampur and Nachhipur village to design and field evaluation of recharge structures.

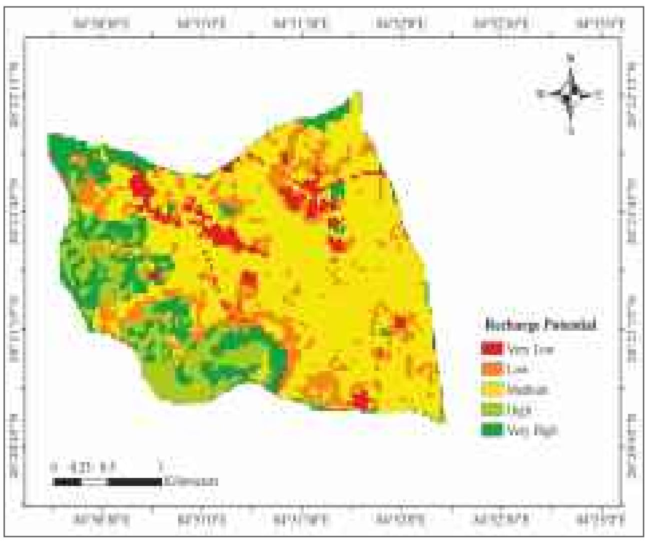


Fig. 24. Delineation of recharge potential zones in Bargharianala micro-watershed

Impact of rainwater harvesting structure along with recharge well was monitored in Srirampur village. In Srirampur village, three number of rainwater harvesting structures (RWHS) were selected and a recharge well with diameter of 1.2 m and depth of 12 m was constructed in one of the structures during the month of April 2017.

Depth-capacity of recharge structures

It was observed that RWHS-1 can store 1480 m^3 and 5600 m^3 of rainwater at minimum and maximum storage depth of 2.7 m and 5 m, respectively. The RWHS-2 can store 644 m^3 and 2000 m^3 of rainwater at storage depth of 1m and 2.1 m respectively, whereas the RWH-3 can store 320 m^3 and 1100 m^3 of rainwater at the storage depth of 0.4 m and 1.6 m respectively. Depth-capacity curve indicates that due to size of the reservoir, initial water quantities get spread over submergence area with little increase in water depth.

Hydrographs of water level in recharge structures

The annual rainfall in the study area was 1054 mm with 53 numbers of rainy days in 2016, whereas in 2017, rainfall was 1340 mm with 69 numbers of rainy days. Hydrographs of water level in recharge structures are shown in Fig. 25. The water level in RWHS-1, 2 and 3 were 3.9 m, 1.4 m and 1 m in the March 2017 against 3.4 m, 1.4 m and 0.6 m in March 2016, respectively. Based on water availability in all the three structures, irrigation water could be provided for 15 ha and 3.5 ha *kharif* and *rabi* crops, respectively.

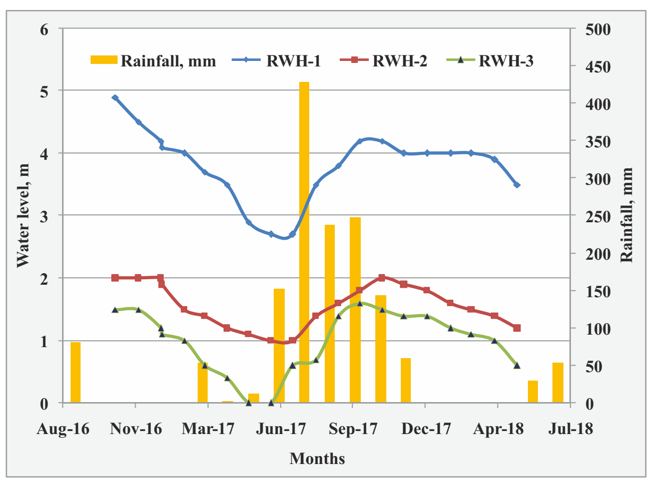


Fig. 25. Hydrographs of water level in recharge structures

Estimation of groundwater recharge

The water table depth was measured in monitoring wells and dug wells located within 5, 10, 50, 100, 200, 300 and 320 m distances from the recharge structures to study the area of influence of the recharge structures with recharge wells. It was observed that there is rise in water table depth upto 0.7 m in dug-wells within the area of influence (15 ha area) of the structures. Based on water table fluctuation method, the groundwater recharge was estimated as 5.7 cm $year^{-1}$ for this area.

Assessment of Groundwater Contamination Due to Excess Fertilizer and Pesticide Uses and Its Management in Lower Godavari Basin

Project Code : IIWM/17/185

Investigators : Abhijit Sarkar, D.K. Panda, S. Mohanty and Seerisha Ambati

Godavari basin is the second largest river basin in India, next to the Indo-Gangetic basin, which accounts for 313 thousand sq. km and it covers seven states of India. The lower reach of basin has been extended to Chhattisgarh, Odisha, Telangana and Andhra Pradesh. The study area (16°18' N to 17°32' N and 81°25' E to 82°22' E) has been chosen under East and West Godavari districts of Andhra Pradesh based on cropping intensity, chemical uses, soil type, groundwater depth and climatic condition, to assess the groundwater contamination from excess use of synthetic chemicals in agriculture. The study area has covered 6852 sq. km and the river stretches approx. 376.16 km over the entire study area. This lower Godavari basin is considered as most fertile and intensively cultivated with average cropping intensity of 172%. This is also considered as the 'rice granary of south India' because of the intensive rice cultivation. The basin area belongs to East Coast Plains and Hill (XI) Zone of India, and Krishna-Godavari Zone (AP-1) of Andhra Pradesh, with 1333 mm mean annual rainfall.

Farmers grow rice extensively during *kharif* season and 'MTU-7029' is the mostly cultivated variety along with 'MTU-1064' throughout the basin. However, 'MTU-1156', 'MTU-1010', 'MTU-1121', 'MTU-1153' and 'MTU-2636' are also some popular cultivars of rice for *rabi* season. Recommended dose of fertilizer is 90:60:40 and 180:90:60 kg ha^{-1} $N:P_2O_5:K_2O$ during *kharif* and *rabi* seasons, respectively for the study area. Apart from rice, farmers grow maize, cotton, tobacco and vegetables also. Surface physiography of landscape was analyzed using

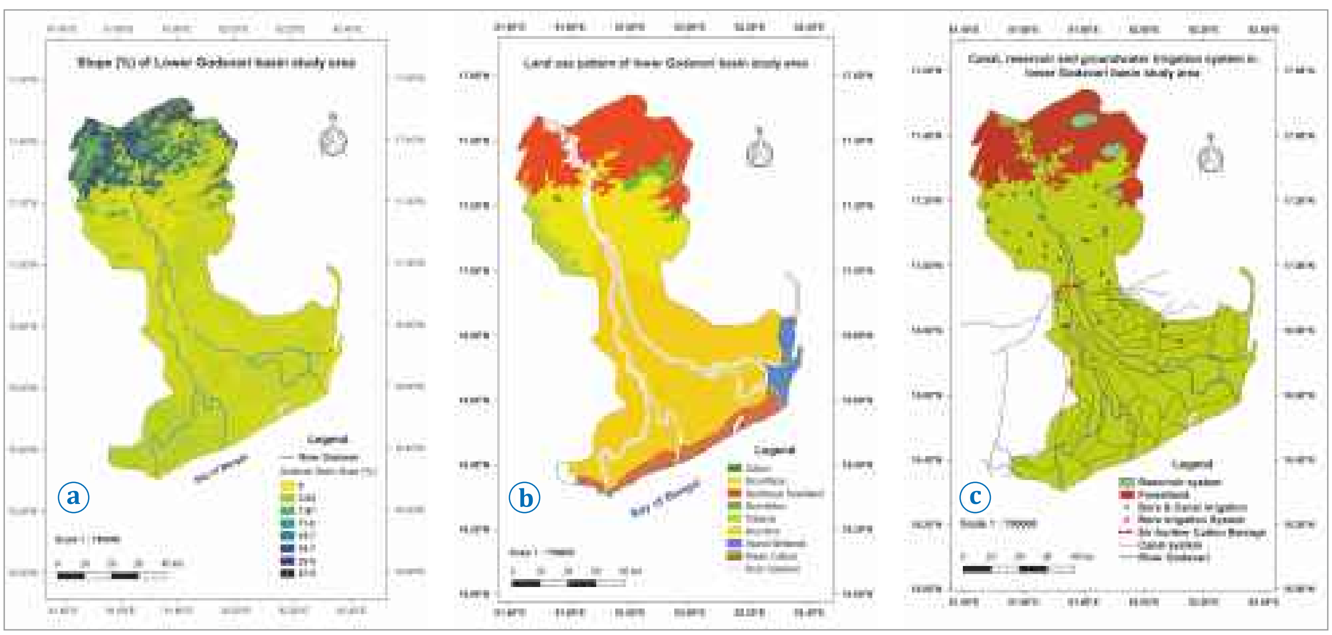


Fig. 26. Thematic map slope percentage (a), land use pattern (b) and irrigation system (c) at lower Godavari basin study area

global Digital Elevation Model (DEM) at 10 m resolution and Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER) from Earth Explorer data base of United States Geological Survey (USGS). The slope of the landscape, contour map with 100 m interval and immediate interval was done separately to know the drainage and hydrology of study area (Fig. 26). Data reveals, major portion of basin area is under gentle slope (<5%) slope, while forest area has moderate (5-15%) to steep (>15%) slope with dry deciduous vegetation. Based on interaction with farmers and secondary data, it reveals that *kharif* rice is rainfed and *rabi* rice or maize/ cotton/ vegetables are irrigated. In the year 2016, groundwater depth varied from 1.21 to 7.44 m, 0.71 to 4.52 m and 0.39 to 3.77 m across the basin from south to north direction during pre-monsoon, monsoon (*kharif*) and post-monsoon (*rabi* and summer) season, respectively (Fig. 27). Use of groundwater for irrigation is more in northern part of the basin. This has led to the depletion of groundwater. Further, nitrate contamination to groundwater is common in this part of the basin. Rampachodavaram, Folkspeta, Dondapudi and Polavaram are some CGWB identified areas with contaminated groundwater, where groundwater is having higher levels of nitrate nitrogen (NO_3^--N) than critical limit (10 mg l^{-1}). High (EC >0.75 dS m^{-1}) to very high (EC >2.25 dS m^{-1}) salinity is a major obstacle to use groundwater in southern part of the basin for irrigation purpose. Thus, utilization of canal water has become mandatory for cultivation of rice during *rabi* season.

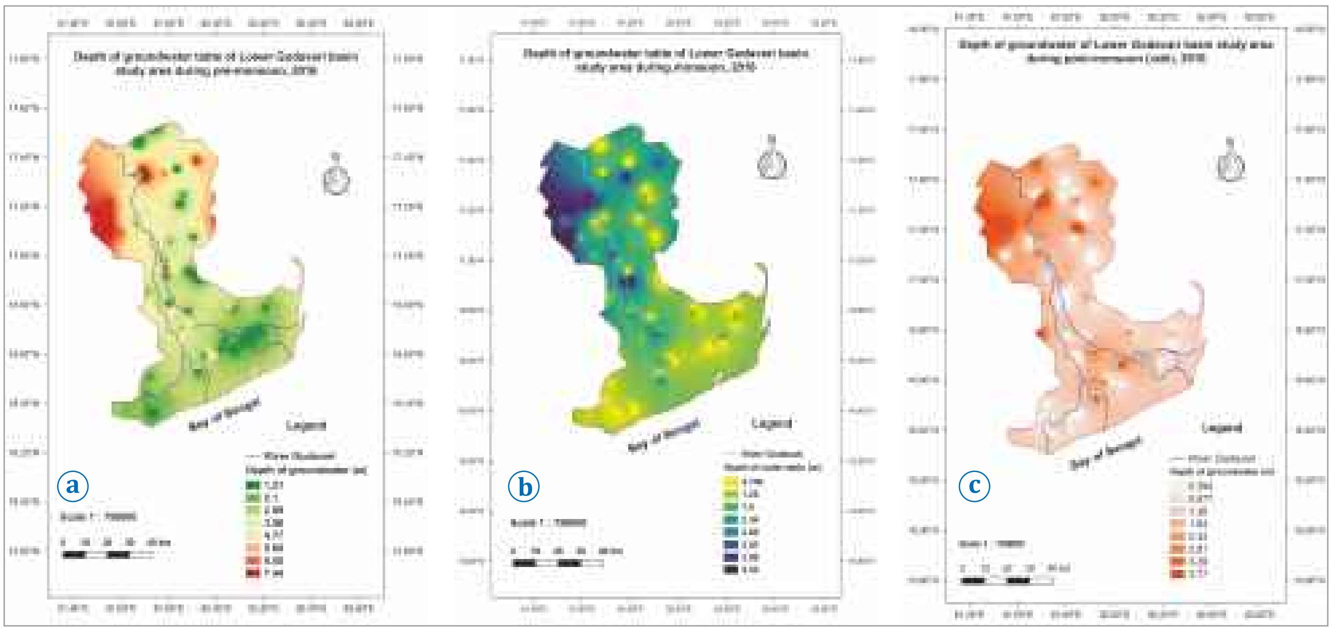


Fig. 27. Thematic map of pre-monsoon (a), monsoon (b) and post-monsoon (c) season depth of groundwater at lower Godavari basin study area

Efficient Groundwater Management for Enhancing Adaptive Capacity to Climate Change in Sugarcane Farming System in Muzaffarnagar district, UP

Funded by DoAC & FW, Ministry of Agriculture & Farmers Welfare, Government of India

Investigators : A. Mishra, S. Mohanty, R.R. Sethi and P. Panigrahi

To enhance adaptive capacity to climate change in a sugarcane based farming system, different interventions have been executed in an overexploited groundwater area (Rasulpur Jattan village) of Muzaffarnagar district, Uttar Pradesh. The interventions include underground conveyance pipe line system, installation of improved irrigation application methods (drip and rain gun), construction of recharge cavities, check dams for artificial groundwater recharge, and development of self-reliant farming system in terms of energy and nutrients uses.

Water budgeting of the study village

In the study village RasulpurJattan, sugarcane is a predominant crop, grown in 168 ha area out of the total 300 ha geographical area and 402 ha gross cropped area. The demands for total irrigation water of crops, and human and animal water needs are met from the groundwater. The groundwater budgeting for the village is presented in Table 12.

Table 12. Groundwater budgeting of Rasulpur Jattan village

Groundwater Components	Quantity (m^3)
Average annual recharge from monsoon rainfall	547200
Average annual recharge from non-monsoon rainfall	185482
Total annual recharge from rainfall, (Row 1+2)	732682
Annual irrigation return flow from non-monsoon crop fields	431758
Total annual recharge Q_{in}, (Row 3+4)	1164440
Annual groundwater pumping for domestic purpose	108916
Annual groundwater pumping for livestock	22539
Annual groundwater pumping for irrigation	1684048
Total annual groundwater pumping Q_{out}, (Row 6+7+8)	1815503
Change in groundwater storage (ΔS), cum (Row 5-9)	(-) 651063
Annual average depth of groundwater depletion, m	1.36

In study village, it was observed that computed water table decline of about 1.36 m annually due to heavy drafting of groundwater for irrigation, domestic and livestock purposes (Table 12). However, decline of water table in the nearby Kakada village was observed 0.35 m, which is significantly lower than the computed value of Rasulpur Jattan village. This discrepancy is possibly due to the presence of canal irrigation system in nearby area that helps in recharging the aquifers of the village.

Assessing the current and future risks due to climate change

The future risk due to climate change and its impact on groundwater table has been assessed for business as usual and various other scenarios.The future climatic data such as daily rainfall, maximum temperature, minimum temperature and solar radiation on earth's surface were collected from the MarkSim Global Climate Model (GCM) at Representative Concentration Pathway (RCP) - 4.5 for the years of 2020, 2030, 2040, 2050, 2060, 2070, 2080 and 2090 using the model Geophysical Fluid Dynamics Laboratory (GFDL) - Global Coupled Model-CM3. Using these climatic data, the reference evapotranspiration for different years were computed and subsequently the irrigation water requirement of major crops grown in the study village was computed.

To predict the future water demand, seven scenarios were formulated considering cultivated area under sugarcane crop, improved irrigation application and conveyance system, and artificial groundwater structures. The following scenarios were considered:

Scenario		Description
1		Business as usual (BAU)
2		50% reduction in sugarcane area
3		50% of the cultivated area to be covered under underground pipe line conveyance system
4		Combining scenario 2 and 3
5		100% of the cultivated area to be covered under underground pipe-line conveyance system
6	(i)	Scenario 4 in combination with installation of one recharge cavity in each 100 ha area
	(ii)	Scenario 4 in combination with installation of one recharge cavity in each 75 ha area
	(iii)	Scenario 4 in combination with installation of one recharge cavity in each 50 ha area
7	(i)	Scenario 5 in combination with installation of one recharge cavity in each 100 ha area
	(ii)	Scenario 5 in combination with installation of one recharge cavity in each 75 ha area
	(iii)	Scenario 5 in combination with installation of one recharge cavity in each 50 ha area

The irrigation water demand for the scenario 6 and scenario 7 will be remain same as the scenario 4 and scenario 5, respectively.

Fig. 28 presents the change in groundwater table depth below ground level for various scenarios which has been arrived from the change in groundwater storage value. In most of the cases, the predicted groundwater extraction is found to be more than the inflow to the groundwater except the case of scenario 6(iii). Reduction in sugarcane area by 50% in combination with improved conveyance and application system and artificial recharge structure has the potential to reverse the declining trend of groundwater table. Besides this analysis, three drip irrigation system has also been installed in the farmer's field.

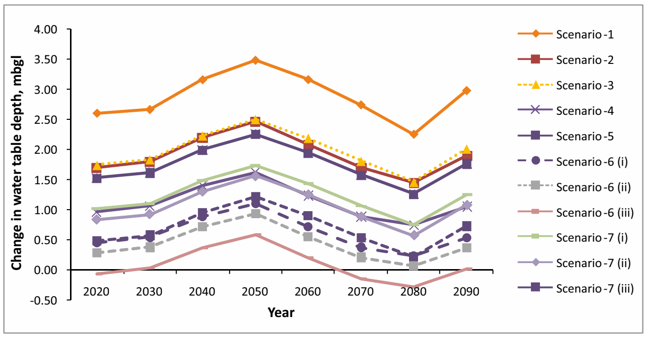


Fig. 28. Future trend of the decline of depth of groundwater table under different scenarios

ON-FARM TECHNOLOGY DISSEMINATION

On-farm Technology Dissemination

This program includes research projects on OFTD, wastewater management, water policy & governance

Impact Assessment Study of Using Industrial Wastewater on Sunflower (*Helianthus annus* L.) and Mustard (*Brassica nigra* L.) Grown in Peri-industrial Area of Angul, Odisha

Project Code : IIWM/15/170

Investigators : Rachana Dubey, Mausumi Raychaudhuri and P.S. Brahmanand

To study the impact of industrial wastewater (WW) in conjunction with freshwater (FW) in different proportion i.e. T1: 0% WW, 100% FW; T2: 25% WW,75% FW; T3: 50% WW, 50% FW; T4: 75% WW, 25% FW and T5:100% WW, 0% FW on soil characteristics was studied through soil incubation study. The wastewater was collected from selected sites in Angul, Odisha in monsoon season. Chemical characteristics of waste water were: pH 3.03, EC 1.12 dS m^{-1}, dissolved oxygen 1.6 mg L^{-1}, NO_3-N 140 mg L^{-1}, NH_4-N 28 mg L^{-1}, P 8.1 mg L^{-1}, exchangeable K 5.5 mg L^{-1}, Ca and Mg 26 and 56.4 mg L^{-1}, respectively. Initial soil characteristics under study was having pH (1:2.5) 6.5, EC (1:5) 0.081 dS m^{-1}, organic carbon 0.23%, available N 177 kg ha^{-1}, available P 18.8 kg ha^{-1}, exchangeable K 131 kg ha^{-1}. Maximum water holding capacity of the soil was 28%. An amount of 100 g soil was incubated in different ratios of freshwater: wastewater using two methods viz., cyclic and mixing at field capacity in six cycles of wetting drying.

Results showed that electrical conductivity (EC) increased significantly from 0.09 to 0.36 dS m^{-1} which was strongly correlated with increase in Na (r = 0.97), Mg (r = 0.88), hardness (r = 0.46) and Fe (r = 0.46) (significant at 5% level) (Table 13). The reason was that a good amount of Na, Mg, K, Fe and Ca ions were present in the wastewater which was collected from the industrial site of Angul, Odisha. Other parameters viz., organic carbon, nitrogen, and phosphorous did not vary significantly.

Table 13. Effect of industrial wastewater in conjunction with freshwater on soil incubation

Treatment	pH (1:2.5)	EC (1:5) (dS m^{-1})	Exchangeable K (kg ha^{-1})	Na (c mole (+) kg^{-1})	Available S (mg kg^{-1})	Ca (c mole (+) kg^{-1})	Mg (c mole (+) kg^{-1})	Fe (ppm)
T1	6.61	0.09	138.7	6.63	14.02	1.1	0.80	1.62
T2	6.79	0.18	149.9	12.74	18.22	1.12	0.95	1.94
T3	6.91	0.23	154.1	15.47	18.03	1.12	1.13	2.19
T4	6.61	0.28	167.1	18.97	22.64	1.15	1.03	2.27
T5	6.6	0.36	169.7	23.94	31.15	1.17	1.18	2.20
LSD (p=0.05)	ns	0.02	14.5	12.64	6.79	0.09	0.23	0.46

Wastewater during the post-monsoon i.e. *rabi* season of 2017-18 was also collected from same site and used for irrigation trial at ICAR-IIWM research farm to assess its impact on soil and oilseeds crop through pot experimentation. Chemical composition was obtained as: pH 6.89, EC 0.41 dS m^{-1}, NH_4-N 12.6 mg $L^{-1}$and NO_3-N 21.7 mg L^{-1}, P 2.76 mg L^{-1}, K 4.01 mg L^{-1}.Pot experiment was conducted with two methods of irrigation water application i.e. cyclic and mixing in five different proportions as T1, T2, T3, T4 and T5 as mentioned above with sunflower (variety 'MSFH 17') and mustard crop (variety 'PT 303') with three replications in a factorial design. Yield attributes like plant height, number of leaves, stem girth were recorded at regular intervals during the crop-growing season. The plant height of mustard and sunflower in general was found to be higher with increasing proportion of wastewater at different growth stages. The maximum significant plant height of mustard was observed at 105 DAS (104.3 cm) and sunflower at 75 DAS (106.9 cm) in T5 which was at par with T4 (98.1 cm in mustard and 102.6 cm in sunflower) over T1 (83.8 cm in mustard and 95 cm in sunflower). The methods of irrigation water application i.e. cyclic and mixing was not significant for all the parameters studied.

Gas exchange traits were measured in sunflower and mustard crop during flowering stage under pot experiment (Fig. 29 a, b, c). Rate of photosynthesis varied significantly from T1 (12.1 µmole CO_2 $m^{-2}s^{-1}$ in mustard and 22.6 µmole CO_2 $m^{-2}s^{-1}$ in sunflower) to T4 which was at par with T5 (16.23 µmole CO_2 $m^{-2}s^{-1}$ in mustard and 31.2 µmole CO_2 $m^{-2}s^{-1}$ in sunflower). Similarly, stomatal conductance was significantly higher in T5 (300.3 and 307.3 mmole $m^{-2}s^{-1}$ respectively in sunflower and mustard) compared to 100% freshwater i.e. T1 (244.7 mmole $m^{-2}s^{-1}$ in mustard and 272 mmole $m^{-2}s^{-1}$ in sunflower). No significant differences were observed in leaf transpiration rate amongst different treatments in both mustard and sunflower.

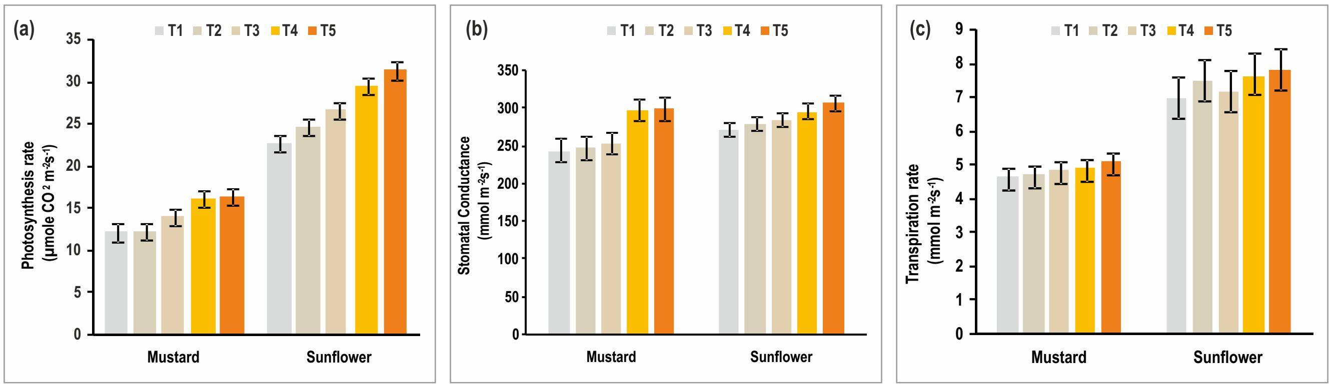


Fig. 29. Effect of industrial wastewater in conjunction with freshwater on rate of photosynthesis (a), stomatal conductance (b), and transpiration rate (c) on mustard and sunflower crop

Developing the Process for Remediation of Chromium from Polluted Water Sources

Project Code : IIWM/15/171

Investigators : Madhumita Das, S. Roy Chowdhury, P.S. Brahmanand and K. Laxminarayana

Occurrence of Cr (VI) in soil and water resources in chromite mines areas, Sukhinda

Thirty-six soil and sixty-six water samples from various sources were collected from different locations at the surroundings of chromite mine areas at Sukinda, Odisha. Considering 10 mg kg^{-1} and 0.1 mg l^{-1} as threshold limits of Cr for soil and water, respectively, around 28% soil and 70% of water were found to have toxic level of Cr (VI) and not suitable for agricultural use.

Study the performance of aquatic plants to remove Cr (VI) from water

An experiment was carried out at varied Cr (VI) concentrations as CrO_4^{-2} ranged from 0.5, 0.75, 1.0. 1.75 and 2.0 mg l^{-1} with equal biomass of (100 ± 5.0 gm) *Salvinia minima, Pistia stratiotes, Ipomoea aquatica* and *Eichhornia crassipes* for a period of 30 days after imposing treatments in water under net house condition. Periodical observations of plant biomass against the treatments reveal that it was reduced by 8 to 27% in *Pistia stratiotes and Ipomoea aquatic*a and increased by 45 to 101% in *Salvinia minima* and *Eichornia crassipes,* respectively irrespective of Cr levels. Besides, *Salvinia minima* was found to accumulate 5 to 7 times more Cr than other plants.

Determining Cr (VI) tolerance level of *Ipomea aquatica* and *Salvinia minima*

Pot experiments were conducted with graded Cr (VI) concentrations ranged from 0 to 5.0 mg l^{-1} keeping 14.5g *Ipomea* and 28.5 g *Salvinia* as initial biomass, for a period of 59 days under net-house environment. In general, growth rate enhanced by 0.78 to 1.5 folds up to 15 days in *Ipomea* and 0.3 to 3.0 times up to 35 days of imposing treatment in *Salvinia*. However the growth rate was overall decreased beyond 1.89 and 2.81 Cr mg l^{-1} for *Ipomea* and *Salvinia,* respectively. The concentration of Cr was decreased with progress of time to the tune of 17 to 70 times without maintaining any trend either with Cr concentration levels or period of observation. However, maximum reduction of Cr in water was found after 38 days of imposing treatments (Fig. 30).

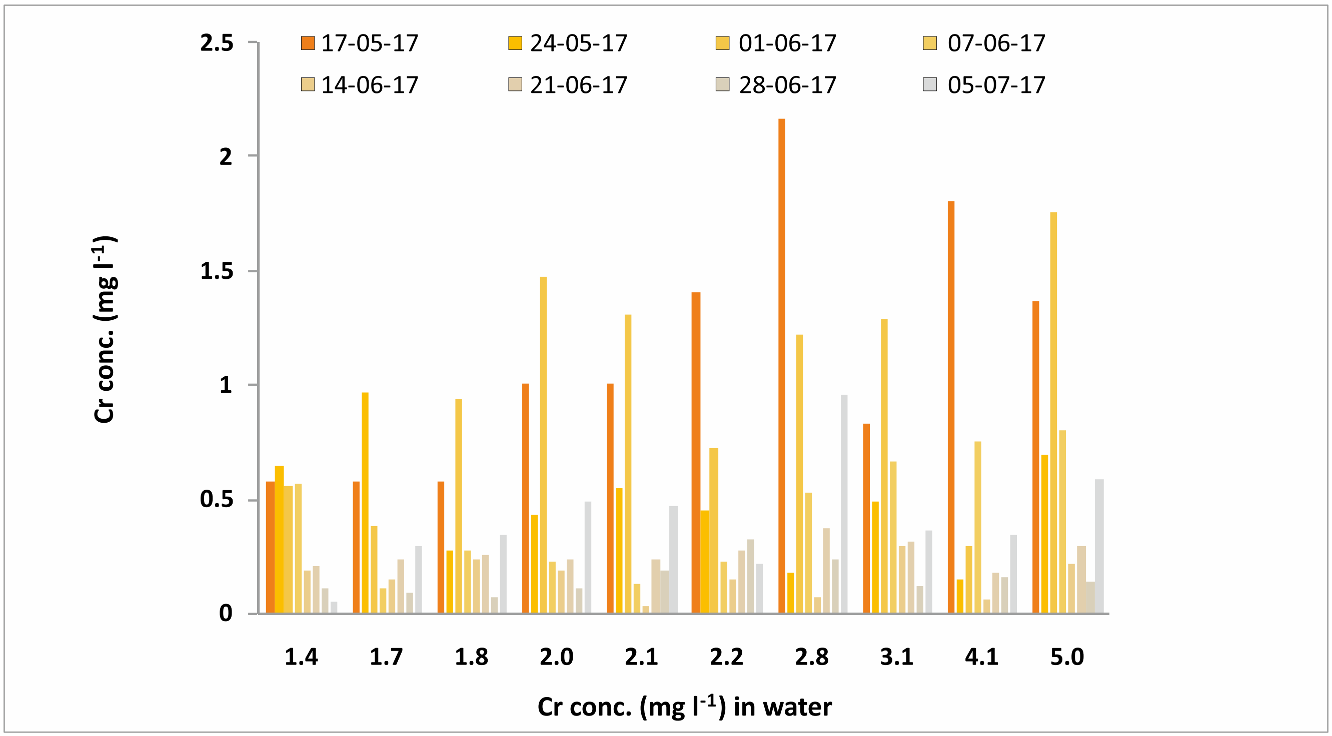


Fig. 30. Change of Cr concentration with time under different levels of Cr in water

Development of Web-based Expert System on Agricultural Water Management

Project Code : IIWM/16/181

Investigators : A.K. Nayak, P.K. Panda and R.K. Mohanty

Development of an expert system in agricultural water management was initiated to catalogue water management practices in agriculture, horticulture, high value aquaculture and animal husbandry. All commercial crop production systems today are potential candidates for expert systems. These expert systems can take integrated crop management decision aids which would encompass irrigation, nutritional problems and insect control application. The system will allow farmers and other stakeholders to interact and can get the solution over the defined problem.

The web page formats of expert system were developed in open access PHP language for better user friendliness and on Wamp Server platform. Modules were developed for displaying crop wise agricultural water management information as shown in Fig. 31. The user has to select the crop, followed by land condition and season. Accordingly the desired information will be displayed in the expert system. Another option was created to search the information on location basis. The user has to select the location on a map upto district level resolution and then select the season. Accordingly the crops grown in the region will be displayed from which the user will get information about water management practices to be followed for individual crop. The android based version of the expert system on agricultural water management was also developed for agricultural crops.

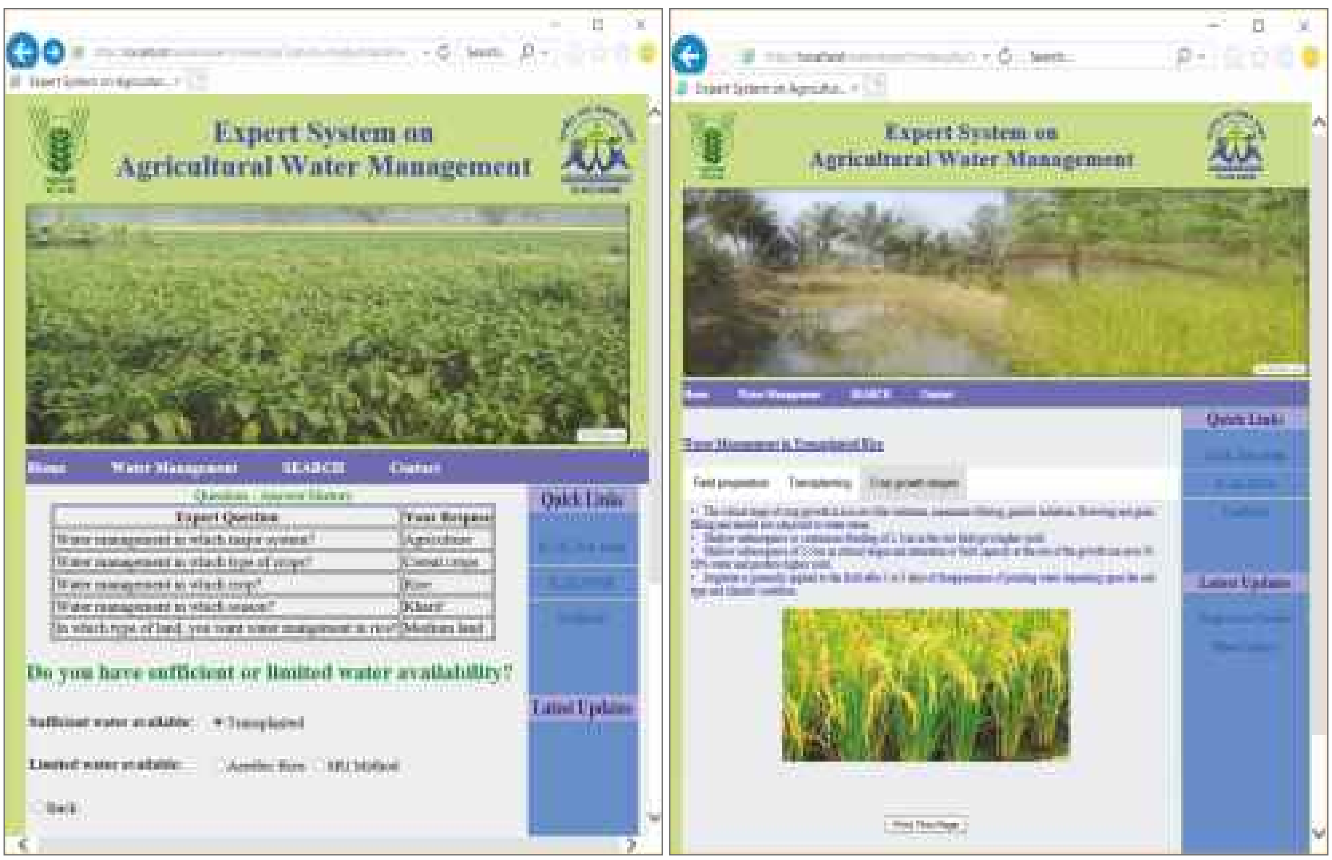


Fig. 31. Search module for water management practices in agricultural crops

Smart Water Management System in Agriculture

Project Code : IIWM/17/186

Investigator : D. Sethi

The project was initiated from August 2017 with an objective of developing a mobile app based remote pump operation system and development of a smart irrigation management system. A physical device was developed and programmed for receiving and updating data from cloud platform to the device and *vice-versa* using HTTP protocol. The device used GSM-GPRS based internet connection using a sim to connect to the cloud platform. An android app was developed to update the database in cloud platform when buttons for switching on and off was touched. The response was, in turn transmitted from the cloud platform to the device, which regulates switching on and off of the pump through electronic relay. The system was tested and demonstrated. It was also presented in international symposium at ICAR-NRRI, Cuttack.

Demonstrating mobile app based remote pump operation system to RAC members

Socio-economic Evaluation of Water Related Interventions under MGNREGS in Odisha

Project Code : IIWM/17/187

Investigators : H.K. Dash and D.Sethi

The MGNREGS is world's largest public works program providing social security net to almost 15% of country's population. But over time, focus of the program has shifted to livelihood security and creation of durable assets such as water resources, land development, orchards and infrastructure. Under the program, 153 work kinds are notified of which 100 kinds are related to NRM and 71 works are water related. With expenditure under the program and the number of assets created increasing, it is important to explain to understand how MGNREGS is contributing to agricultural growth. Since creation of water assets is one of the important interventions, the project attempts to understand the pattern and structure of expenditure on water/NRM related interventions; assess the socio-economic impact of water related interventions and study technology/asset management related issues in the context of sustainability of interventions.

In Odisha, expenditure under MGNREGS almost doubled in 2015-16 as compared to 2014-15 and in 2017-18, the expenditure crossed ₹25000 lakh. If expenditure on NRM and agriculture works is considered, till 2014-15 the entire expenditure in agriculture was on NRM (Fig. 32). But afterwards there was divergence between proportion of expenditure on agriculture & allied works and NRM works. This was more pronounced in 2017-18 which indicates that NRM works including water related ones are not receiving due priority Odisha. Importantly, data suggest that the expenditure on public water related works has declined over the years, which is a matter of concern.

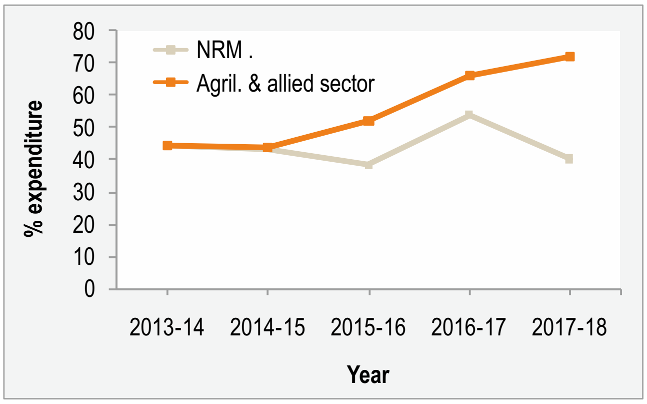


Fig. 32. Percentage of MGNREGS expenditure on NRM and agriculture & allied sectors

Enhancing Land and Water Productivity through Integrated Farming System (Tribal Sub-plan Project)

Investigators : R.K. Panda, R.R. Sethi, S.K. Rautaray and R.K. Mohanty

A field demonstration-cum-training program on 'Pump operation, maintenance and irrigation application techniques' was conducted at Birjaberna village in Sadar block, Sundargarh under TSP project during November 29-30, 2017. The program was attended by 100 farmers including 20 women participants. Different irrigation water application techniques, field demonstration on water application methods in different crops, crop water requirement and aquaculture practices to enhance the farm income were also briefed to the famers during the training program.Pipe conveyance facility was extended in two TSP villages by providing HDPE pipes with quick action coupler to 24 tribal farmers having irrigation sources for encouraging to adopt pipe irrigation system instead of flooding irrigation.

HDPE pipes provided for irrigation purposes

Capacity building training programme

Water pump trouble shooting is explained

Tribal farmers were explained benefits of furrow irrigation system

Enhancing Water and Livelihoods Security and Improving Water Productivity in Tribal Dominated Paddy Fallow Rainfed Agro Ecosystem of Odisha (Farmer's FIRST Project)

Investigators : P. Nanda, D. Sethi, A. Mishra, S. Mohanty, M. Das, R.K. Mohanty, P.S. Brahmanand, A.K. Thakur, A. Das and B. Das

Line transplanting, SRI method, application of proper dose of fertilizers and use of cono-weeder were included in the intervention in rice cultivation. Out of 19 farmers, 13 farmers who had adopted the improved practices in rice cultivation. Brinjal seedlings were distributed to 25 farmers, of which 19 farmers could maintain till production. Due to shortage of water, production could be sustained till end of January. Data was collected from 14 brinjal farmers. Average increase in gross income from horticulture was found to be 101.49 % (Table 14). It clearly indicates importance of vegetable cultivation in doubling farmer income.

Table 14. Increase in income due to interventions in rice cultivation and horticulture

Interventions	No of Farmers	Range of increase in income (₹)	Average increase in income (₹)	Range of increase in income (%)	Average increase in income (%)
Only Paddy	13	6000 - 18000	9646.15	6.67 – 25	13.14
Paddy + Brinjal	14	6400 - 38400	21257.14	19.5-320	101.49

Scientific fish farming was initiated in three community ponds by three water user groups. 7000 fries and 3 quintal feed was distributed. Sampling indicated the average weight of fish to be 275 g in 4 months. Three water pumps along with conveyance pipes and 10 cono-weeders were provided to farmer groups. Nine power thresher cum winnowers were procured for drudgery reduction.

Four trainings were imparted to farmers and farm women in the project area. A total of 401 farmers including 126 farm omen were trained on agricultural water management and income generating activities in agriculture. Social media was used through “Whatsapp group” for communicating problems to scientists and solutions to farmers. Video films of successful farmers were prepared as motivation for other farmers. One information brochure was also prepared regarding the activities of the project. Three news were published in local news papers. One convergence meeting was organized for all state line departments for collaborative work in the project area. All the line departments were also involved during the training programs. Scientists regularly visited the project area and facilitated participatory problem solving. Innovative farmer Meena Mohanta of Village Khuntapingu received best farmer award on the occasion of 'World Water Day 2018' celebrated by International Water Management Institute in collaboration with ICAR-IIWM.

Activities under Farmer's FIRST project

Revival of Village Pond through Scientific Interventions

Externally funded project: DST, Ministry of Science & Technology, New Delhi

Investigators : S.K. Jena, P. Nanda, P.S. Brahmanand and S. Mohanty

A network research project was initiated at ICAR-IIWM, Bhubaneswar with objectives of preparation of inventory and status of ponds in the selected villages representing different agro-ecological regions including analysis for their dysfunction; to assess and document indigenous knowledge of construction, management and use of village ponds; to identify and demonstrate scientific interventions on a pilot basis for revival of the village ponds and ensuring community participation; and to create awareness and disseminate knowledge to the stakeholders.

The implementation of the project is directly undertaken in participatory mode in consultation with government departments. Kendrapra and Puri are the two districts present in the coastal belt of the Odisha. In the coastal belt seawater intrusion and waterlogging are the common problems in general and Kendrapada and Puri districts in particular. In both the district the sites are present in the deltas of Mahandi river. These sites are more vulnerable to the natural calamities like, flood, cyclone etc.

Interaction meetings were held among the scientists involved in the project as well as the villagers and gram panchayat office bearers to select sites for study. In Kendrapada district, two sites were selected for the project. One at Garadapur gram panchayat and another at Madana village. The pond at site-1 (near Garadapur G.P.) present over an area of 4.20 ha and use by the local people. It is used for bathing and washing of clothes etc. The pond at site-2 (Madana village) is present over an area of 0.20 ha. It is also used by the villagers for their house hold requirement, bathing etc. Both the ponds were full with water hyacinth and other aquatic plants. The ponds were not cleaned so, the condition of the pond water was also not good for domestic use. In Puri district one pond was selected (0.085 ha) for the project in Kapileswarpur gram panchayat. The study area is about 8 km away from the Bay of Bengal and about 0.3 km away from river Bhargabi.

A dumpy level survey was initiated to find out the actual catchment area of the pond. Soil and water samples were collected for primary analysis. The sediment of the pond at Garadpur varies from sandy loam to clay loam. The pond silt is clay loam at Madana village and loam at Kapileswarpur. With the co-operation and active participation of gram panchayat, pond was cleaned and the water hyacinth and other aquatic plants were removed from the pond. Aquaculture has been taken by the villagers in those ponds.

Weed infested village pond (Satellite image of February 13, 2016)

Water hyacinth and other aquatic weed removed from village pond at Garadpur, Kendrapada

AICRP ON IRRIGATION WATER MANAGEMENT

AICRP on Irrigation Water Management

The AICRP on Irrigation Water Management (AICRP-IWM) scheme is in operation in nineteen agro-ecological regions of the country. Twenty six centers of AICRP-IWM carried out research and extension work in the field of assessment of water availability, groundwater recharge, groundwater use at regional level, evaluation of pressurized irrigation system, groundwater assessment and recharge, water management in horticultural and high value crops, basic studies on soil, water, plant relationship and their interaction, conjunctive use of canal and underground saline water, drainage studies for enhancing water productivity, enhancing productivity by multiple use of water, and rainwater management in high rainfall areas.

Salient Achievements

- Water availability, demand-surplus analysis of Retamunda Branch Canal System was carried at the distributary levels by Chiplima centre. It was observed that water deficit condition prevails in head and middle reaches of the canal command, with surplus water in the tail reach. To maximize net returns under the limited land and water availability constraints, it is feasible to provide irrigation to the entire command area even though canal releases are reduced by 40%. This can be achieved by reducing the cropping area under heavy duty crops from 8861 to 2975 ha, and increasing the area under medium duty crops (from 2180 to 4820 ha) and light duty crops (from 231 to 3471 ha).

- Kota centreof AICRP-IWM studied water availability and deficit at field level for Manasgaon distributary of right main canal. Water supplied in the distributary during November 2016 was maximum (15223.31 ha-cm) and minimum during October 2017 (5799.03 ha-cm). Relative water supply (RWS) was maximum (98.75 %) in October 2017 with only 6 canal running days, whereas RWS was minimum (36.79%) in March 2017 with 17 days of canal running. Thus canal water availability at field level during *rabi* 2016-17 was 28391.63 ha-cm and during *kharif* 2017 it was only 3189.47 ha-cm. Area sown under different crops in this command area was 1065.93 ha during *rabi* season, out of which wheat and mustard occupied maximum area. Similarly, the total sown area during *kharif* was 1012.02 ha, out of which soybean and paddy covered maximum area. Season-wise water availability at field level through canal and rain and the total water requirement of crops showed that the total water deficit of 14677.0 ha-cm and 10012.0 ha-cm was observed during *rabi* and *kharif* seasons, respectively.

- Carbon emissions for groundwater pumping in different zones of Punjab were estimated by Ludhiana centre. The study revealed that a fall of groundwater level by one meter would increase C-emission rate by 2.67 g m^{-3}. Increase in energy requirement for groundwater pumping was directly proportional to C-emissions in different zones of Punjab. An increase in energy for groundwater pumping by 350, 214 and 158% led to C-emissions by 470, 229 and 269% from year 1998 to 2013, respectively.

- Experiment was undertaken by Rahuri centre to develop pressure-discharge relationship for dripper and micro-tubes and to evaluate its performance. The flow rate through the emitters and micro-tubes under different operating pressure (0.2, 0.4, 0.6, 0.8 and 1.0 kg cm^{-2}) was measured. The performance of drip system with emitter was evaluated by measuring discharge at 12, 18, 24, 30 and 36 m length of lateral and for micro-tube, performance was evaluated at 12, 18, 24 and 30 m length of lateral. It was observed that as the operating pressure increased corresponding discharge increased. When pressure increased from 0.2, 0.4, 0.6, 0.8 and 1 kg cm^{-2} the corresponding discharge observed were 2.13, 3.12, 4.11, 4.25 and 4.58 lph, for emitters and 5.65, 6.81, 7.52, 8.46 and 9.2 lph for micro tube, respectively. The discharge exponent of the emitters was 0.49 indicating non-pressure compensating nature of the emitter whereas the discharge exponent for the micro tube was 0.30, indicating it's non-pressure compensating nature. The overall emission uniformity obtained in the range of 86.90 to 93.88% for the emitters and around 92% for micro-tubes.

- At Navsari, an experiment was conducted with subsurface laterals having inline drippers of varying discharge rates and spacings to prevent damage to surface drip system. With subsurface lateral system, sugarcane yield ranged from 145 to 159 t ha^{-1}, whereas yield with surface lateral was 150 tha^{-1}. Cane yield was highest (159 tha^{-1}) with the combination of higher discharge rate of 4 lph and higher dripper spacing of 60 cm. Increase in dripper spacing and dripper discharge rate under subsurface lateralplacement gradually increased cane yield. This study revealed that subsurface placement of laterals with inline drippers is economically viable for sugarcane cultivation. Juice analysis showed that different combinations of drip discharge rates (1.3, 2.0 and 4.0 lph) and dripper spacings (40, 50 and 60 cm) did not have significant effect on CCS value in sugarcane juice.
- At Belavatagi, two years of experiment with onion (var. *Arka Kalyan*) grown in paired row (45-120-45 cm) on raised bed and drip irrigated at 0.8 ET_o and 1.0 ET_o showed significantly higher yields of 54.29 t ha^{-1} and 51.31 t ha^{-1}, respectively over the yield of 43.96 t ha^{-1} with farmers' practice. The experiment showed that sole crop of chilli (var. *Byadagi Dabbi*) recorded significantly higher yield of 1.76 t ha^{-1} over intercropping system of Chilli+Onion+Cotton (0.67 t ha^{-1}). Equivalent yield of chilli (2.98 t ha^{-1}) was also significantly higher than yield with Chilli+Onion+Cotton with higher net return of ₹ 3,04,857 and B:C ratio of 3.16 when drip irrigation was applied at 0.8 ET_o. The results have been recommended for package of practices for the farmers of Malaprabha command area.
- At Belavatagi, four years of experiment showed that irrigation at 0.8 IW/CPE and 0.6 IW/CPE resulted in significant increase in seed yield of sunflower (1.72 and 1.62 t ha^{-1}) as compared to rainfed ecosystem (1.42 t ha^{-1}). Among *in situ* moisture conservation systems, broad bed furrows with incorporation of sunhemp resulted in significantly higher grain yield of 1.76 t ha^{-1}, water use efficiency of 4.83 kg ha-mm^{-1}, net return of ₹ 27864 ha^{-1} and B:C ratio of 2.42 than other land configurations.
- At Powarkheda, sowing of chickpea variety JG 130 on 15th November and 30th November gave higher seed yields of 2.9 t ha^{-1} and 2.8 t ha^{-1}, respectively than to sowing on 15th December (2.0 t ha^{-1}). Two irrigations i.e. one at branching stage and another at pod formation stage proved to be the best treatment with seed yield of 2.8 t ha^{-1}. In case of availability of single irrigation, it should be applied at the pod formation stage (2.6 t ha^{-1}). Net monetary return of ₹ 65,621 ha^{-1}, B:C ratio of 2.75 and water use efficiency of 127 kg ha-cm^{-1} were maximum when sowing was done on 15th November. Two irrigations gave net return of ₹ 60,506 ha^{-1}, B:C ratio of 2.60 and WUE of 112 kg ha-cm^{-1}.
- A filter has been fabricated and tested with seven combinations at Pusa centre. Analysis revealed that filter combination of coloured gravel, sand and charcoal had maximum recharge rate of 9342 l h^{-1} and second lowest TSS value of 224 mg l^{-1}. Filter combination of coloured gravel, white gravel and sand was best in reducing turbidity of water by 81.7%.
- At Rahuri, performance evaluation of filter technology for artificial groundwater recharge through borewell on the farm/field was done to test hydraulic performance of filter technology for bore well recharge on farm/field and to study the effectiveness of developed filter on farm/field. The four-layer filter comprised of Brick flakes (BF-I) of size 24.28 mm, Sand (SG-I) of size 0.6-2.0 mm, Angular Gravel (AG-I) of grade 9.5-15.5 mm and Pea Gravel (PG-I) of size 20-24 mm. Each layer had thickness of 25 cm, with total thickness of 100 cm. Average filtration efficiency of the filter at Location I and II were 85.81 and 79.23%, respectively. The four-layer filter tested at three different locations in the command area showed filtration efficiency of about 84.49%, which was considered as a satisfactory performance with recharge capacity of 15,11,525 L during the rainy season of 2017.
- To monitor the water table fluctuations and quality of groundwater, 25 wells from command area of distributaries No. 14 to 21 of Left Bank Canal of Jayakwadi Irrigation Project and 5 wells from adjacent non-command area were selected by Parbhani centre. The study area comes under Ambad Tahsil of Jalna

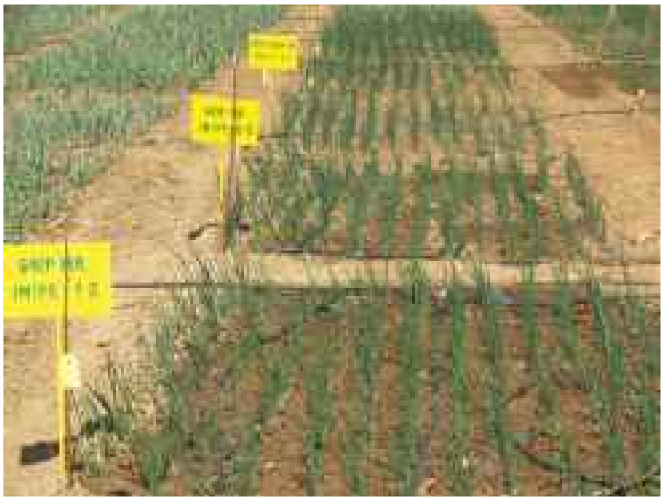
district. Groundwater level in the command area (5.1 to 7.2 m) was higher during March 2017 due to recharge from canal water. During the month of March, in spite of release of water in the canal, the water table depth increased to 6.08 in the command area due to exploitation of well water for *rabi* summer crops. The study area has many orchards of sweet orange. Most of the farmers are utilizing well water through drip for sweet orange in this year. Sugarcane was consistently cultivated in the area due to presence of co-operative sugar factory. Watermelon and vegetable crops were cultivated in the area summer on canal water. Groundwater from Jayakwadi command and non-command area is categorized as C_3S_1 and C_2S_1 as high and medium salinity indicating restrictions on its use for irrigation.

- Groundwater recharge through farm pond was assessed on farmers' field. Three farm ponds of varying size were constructed at farmers' fields in Bhinder block of Udaipur district. The depth capacity curve of identified structures was prepared after conducting the topographical survey of the submergence area. The average recharge rate with the constructed pond was 17.10 mm day^{-1} whereas, net recharge volume was 3061 m^3. Analysis of the water table data showed that 1750 m^3 of harvested water in the pond was utilized for providing irrigation to *rabi* crops grown by the farmer. The pre and post-monsoon groundwater samples were analyzed to check the impact of recharge structure on groundwater quality. The pH of the groundwater varied from 7.8 to 8.5 in pre-monsoon and 7.6 to 8.4 in post-monsoon season.

- Performance of onion crop was studied at Almora with different irrigation schedules based on drip and check basin irrigations. Mean onion yield (23.8 t ha^{-1}) under drip irrigation treatments was significantly higher in comparison to check basin irrigation treatments (15.3 t ha^{-1}). Treatment with drip irrigation scheduled at 1.2 IW: CPE showed highest yield of 27.1 t ha^{-1} followed by drip irrigations scheduled at 1.0, 0.8 and 0.6 IW: CPE, respectively. Lowest yield of 11.1 t ha^{-1} was recorded under check basin irrigation scheduled at 0.8 IW:CPE. Also, drip at 1.2 IW: CPE resulted in 77% increase in WUE and 143% higher income compared to check basin irrigation.

- At Chalakudy, conjunctive effect of micro irrigation, mulching and mycorrhizal inoculation in influencing the yield and economics of vegetable cowpea was studied. Results showed that mulching and mycorrhizal application helped to reduce the irrigation requirement of cowpea by 20% without affecting its productivity and profitability. It was concluded that during summer season cowpea can be cultivated with irrigation at 80% PE without affecting its productivity. Mulching and mycorrhizal inoculation alone had no significant influence on reducing the irrigation requirement. But when applied in combination helped to reduce water requirement of cowpea by 20%. Cowpea with irrigation at 80% PE along with mulching and mycorrhizal application increased yield by 29%, WUE by 38% and NUE in terms of productivity factor by 17% compared to cowpea receiving irrigation at 100% PE without mulching and mycorrhizal application.

Rajmash crop under drip irirgation in Faizabad



Onion crop under drip irrigation system at Almora

Vegetable cowpea under the conjunctive effect of microirrigation, mulching and mycorrhizal inoculation at Chalakudy

- Effect of drip irrigation and surface irrigation on yield of rajmash beans was studied at Faizabad. Drip irrigation @ 60% PE with 100% recommended dose of Nitrogen (RDN) resulted in significantly higher yield of Rajmash beans (13.48 t ha^{-1}) in comparison to surface irrigation at 0.8 IW/CPE (8.7 t ha^{-1}) and drip irrigation at 40% PE (9.9 t ha^{-1}), but was at par with drip irrigation at 80% PE (12.7 t ha^{-1}) at both 80% and 100% RDN. Nitrogen doses (100% and 75% RDN) did not have significant effect on yield of beans in both drip and surface irrigation treatments.
- Bathinda centre studied conjunctive use of canal water (CW) and poor quality tube well water (TW, RSC=1.36 meq l^{-1} and EC=4.2 dS m^{-1}) on summer squash (var. Punjab Chappan Kadoo-1) during *rabi* season. Crop yields were significantly different among the water treatments. On an average, the observed summer squash yield was 9.42 t ha^{-1} with CW followed by 6.88 t ha^{-1} with alternate irrigation of CW and TW and 5.26 t ha^{-1} with TW alone. Among different fertigation schedules, summer squash yields under fertigation levels of 80% and 100% RDN were at par i.e. 7.96 and 7.48 t ha^{-1}, but significantly higher than fertigation level of 60% RDN i.e. 6.12 t ha^{-1}.
- At Chiplima, significantly higher yield (0.70 t ha^{-1}) of blackgram (cv. *Prasad*) was obtained with 100% RDF (20-30-30 N-P_2O_5-K_2O kg ha^{-1}) plus biofertilizer (*Rhizobium*+PSB). Also, it gave highest water productivity of 0.29 kg m^{-3}, net return of ₹ 20644 ha^{-1} and B:C ratio of 2.45 among the nutrient treatments. Compared to farmers' practice of not using any fertilizer and irrigation, use of 100% RDF and *Rhizobium* + PSB resulted in 73.0, 137.6 and 77.8% increase in seed yield, net return and water productivity, respectively. Thus, application of irrigation at IW/CPE 1.0 and 100% RDF along with biofertillizer may be adopted for blackgram crop region.

Drip irrigated summer squash at Bathinda

AGRI-CRP on Water

AGRI-CRP ON WATER

Development and Management of Integrated Water Resources in Different Agro-ecological Regions of India (Theme-I)

Investigators : S.K. Jena, S. Mohanty, P.S. Brahmanand, R.R. Sethi and S.K. Ambast

Collaborating Institutes: ICAR-IISWC, Dehradun; ICAR-CRIDA, Hyderabad; ICAR-RC NEHR, Barapani; ICAR-NBSSLUP, Nagpur; IIT, Kharagpur; PDKV, Akola

Installation and evaluation of innovative water harvesting structures such as rubber dams in different agro-ecological regions were done under this project. The additional water storage capacity created at Palampur-1, Plampur-2 and Dapoli are 4200 m^3, 3600 m^3, 20000 m^3, respectively. The impact of ICAR flexi-check dam on agricultural performanceis reported here for Chandeswar, Khurda district, Odisha (East-coast plains) and Jogiput, Koraput district, Odisha (Eastern-plateau and hills region). During *kharif* season, the rice grain yield was found to be enhanced from 4.14 t ha^{-1} during pre-installation period to 4.93 t ha^{-1} during post-installation of rubber dam resulting in 19% improvement due to optimum time of transplanting and assured irrigation during mid-season dry spells. During *rabi* season, the pod yield of green gram was found to be enhanced by 23% from 0.72 t ha^{-1} to 0.89 t ha^{-1}. At the same time, the yield of brinjal and ridge gourd were enhanced by 37% (from 7.4 t ha^{-1} during pre-installation period to 10.1 t ha^{-1} during post-installation of rubber dam) and 43% (from 6.1 t ha^{-1} during pre-installation period to 8.7 t ha^{-1} during post-installation of rubber dam), due to assured irrigation from rubber dams.

The rubber dam has also resulted in positive impact on productivity of summer vegetable crops such as brinjal (27%), watermelon (32%) and cowpea (36%) at Chandeswar. Similarly, the yield of ridge gourd and pumpkin was found to be enhanced by 36% and 29%, respectively due to assured water supply from the installed rubber dams compared to their average productivity in the area in absence of rubber dam. The fruit yield of ridge gourd was enhanced from 5.5 t ha^{-1} to 7.2 t ha^{-1}, whereas yield of pumpkin improved from 6.3 t ha^{-1} to 8.4 t ha^{-1}. The installation of rubber dam resulted in improvement in cultivated land utilization index (CLUI) from 43.3% (pre-installation) to 57.4% (post-installation) period.

The farmers in Jogiput, Odisha could cultivate vegetables crops like brinjal (32% additional yield from 12.6 t ha^{-1} to 16.6 t ha^{-1}), potato (17% additional yield from 16.1 t ha^{-1} to 18.8 t ha^{-1}) and tomato (24% additional yield from 14.5 t ha^{-1} to 18 t ha^{-1}) in an additional area of 4 ha during *rabi* season due to assured irrigation provided by rubber dam. Moreover, crops in the command of rubber dams installed at different locations are shown.

Crops in rubber dam command of Kanse, Maharashtra

Crops in rubber dam command of Navsari, Gujarat

Two water harvesting structures, one check dam cum rubber dam and one recharge well were constructed in Dhenkanal district, Odisha. Maximum water level during monsoon season was recorded up to 2.3 m and 2.9 m with water storage of 4200 m^3 and 3300 m^3 in the Khallibandha and Khamar water harvesting structure, respectively. Stored water were used for pisciculture, on-dyke horticulture and supplementary irrigation during *kharif* season.

Crops in rubber dam command of Jogiput, Koraput, Odisha

Evaluation of Irrigation System and Improvement Strategy for Higher Water productivity in Canal Commands (Theme-II)

Investigators : R.K. Panda, S.K. Rautaray, P. Panigrahi, S. Raychoudhuri, M.K. Sinha, A.K. Thakur, R.K. Mohanty, O. P. Verma and S.K. Ambast

Collaborating Institutes : ICAR-RCER, Patna; ICAR-CSSRI, Lucknow Centre; ICAR-NRRI, Cuttack; ICAR-IISR, Lucknow; ICAR-IIWBR, Karnal

An experiment was conducted to ascertain the best time to irrigate the rice crop using AWD method without any loss in grain yield. Three levels of AWD viz., water level at 5-cm, 10-cm and 15-cm below the soil surface before re-flooding were tried in the experiment. The top 15 cm of the PVC pipe was above the soil surface level and bottom 25 cm was below the soil surface in the experimental field with transplanted rice. A standing water level of 5 cm was provided through surface irrigation, when water level inside the PVC pipe reached the critical level. The results revealed that rice grain yield was similar to continuous submergence with AWD (4.33-4.50 t ha^{-1}), if the water level inside the perforated PVC pipe was 5 cm below the soil surface. When the water level inside the PVC pipe was allowed to fall to 10 or 15 cm, there was decrease in grain yield (3.97 t ha^{-1}) as compared to continuous submergence. Thus, the safe level of AWD was 5 cm below the soil surface to economize in water use and achieving grain yield similar to submergence condition.

During *rabi* season 2018, groundnut and linseed were grown in the command area and performance of pipe conveyance based irrigation, sprinkler and drip irrigation systems were studied in upper, middle and tail reaches as compared with conventional flood irrigation system in the command.

PVC irrigation conveyance based drip irrigation in groundnut

Automatic Irrigation and Fertigation in Drip-irrigated Banana (Theme-III)

Investigators : P. Panigrahi, S. Raychaudhuri, A.K. Thakur, A.K. Nayak, P. Sahu and S.K. Ambast

Collaborating Institutes : ICAR-IIHR, Bangalore; ICAR-IIVR, Varanasi; ICAR-NRCP, Solapur

Studies were carried out to evaluate the performance of automatic irrigation (sensor based and timer based), variable rate fertigation, and different plant density with different wetted zone/volume (WV) under drip irrigation in banana cv. Grand Nine at ICAR-IIWM research farm at Mendhasal, Bhubaneswar. In the first experiment, soil water sensor based irrigation and timer based auto irrigation (1 hr interval 3 times daily at 80% ETc, 2 hr interval 2 times daily at 80% ETc, 1 h interval 3 times daily at 60% ETc, 2 hr interval 2 times daily at 60% ETc) were compared with manually operated drip irrigation in the crop. In the second experiment, phenology based variable rates of irrigation (60 and 80% ETc at pre flowering; 80 and 100% ETc at flowering and fruit setting; 60 and 80% ETc at fruit development) integrated with fertigation (60 and 80% recommended dose of fertigation at pre flowering; 80 and 100% of recommended dose of fertigation at flowering and fruit setting; 40 and 60% recommended dose of fertigation at fruit development) were compared with normal irrigation and fertigation schedule in the crop. In the third experiment, different plant density (3333, 5000 and 6000 plants ha^{-1}) with different WV (20, 40, 60 and 80%) were compared.

The hydraulic performance of the drip system was studied from time to time and found satisfactory with emitter flow rate variation of 4%, co-efficient of variation of 5% and distribution uniformity of 96%. The water applied under automatic irrigation treatments was 490–670 mm compared with 820 mm in manually operated drip system. The volumetric soil water content (SWC) under manually operated system was marginally higher (21-23%) than that in sensor based irrigation (19-21%) and timer based irrigation (16-22%) treatments. The available nutrients (N, P and K) in soil were higher under sensor based irrigation, whereas light interception and SPAD values were higher in manually operated irrigation system. The vegetative growth (plant height, canopy diameter, number of leaves, stem girth, leaf area index) of the plants under manually operated system was 8-15% higher than that in automated irrigation treatments. However, the sensor based irrigation produced 15% higher yield (69.8 t ha^{-1}) with better quality fruits (higher TSS and lower acidity), resulting in 40% improvement in water productivity compared with manually operated irrigation (Table 15).

Under variable rate of irrigation and fertigation, it was observed that irrigation at 60% ETc during pre-flowering (PF) and fruit development (FD) with 80% ETc at flowering and fruiting stage (F&FS) integrated with fertilizer application at 80% of recommended dose of fertigation (RDFG) at PF with 100% RDFG during F&FS and 60% RDFG at FD stage produced the fruit yield (59.3 t ha^{-1}) which was statistically at par ($p > 0.05$) with that in full irrigation (FI) with RDFG. However, the superior fruit qualities (TSS, acidity) and higher water productivity (20%) were observed in differential irrigation with fertigation treatment in compared to FI with RDFG. The vegetative growth of the fully irrigated plants with RDFG was 5-10% higher than that in variable irrigation and fertigation treatment. The SWC, available N, P and K in soil, light interception and SPAD were higher under FI with RDFG compared with other treatments. Among different planting techniques (1 plant, 2 plants and 3 plants pit^{-1}) with plant density of 3333, 5000, 6000 plants ha^{-1} and WV, 2 plants pit^{-1} (5000 plant ha^{-1}) with 60% WV could produce 35% higher yield resulting 40% higher water productivity compared with normally planted banana.

Table 15. Growth, yield, fruit quality and water productivity of banana under automatic irrigation

Irrigation Treatments	Water applied (mm)	Vegetative growth		Yield (t ha^{-1})	WP (kg ha-mm^{-1})	TSS (^{0}Brix)	Acidity (%)
		PH (m)	CD (m)				
Sensor-based irrigation at 20% ASWD	670	2.11	1.77	69.84	87.3	18.70	0.70
1 h interval 3 times daily at 80% Etc	660	1.97	1.65	63.57	78.5	18.84	0.72
2 h interval 2 times daily at 80% Etc	660	1.92	1.60	62.88	77.6	18.71	0.75
1 h interval 3 times daily at 60% Etc	490	1.65	1.52	54.64	85.3	17.20	0.92
2 h interval 2 times daily at 60% Etc	490	1.62	1.50	54.07	83.1	17.11	0.90
Manual irrigation	820	2.25	1.84	60.51	62.0	17.51	0.79
$CD_{0.05}$	----	0.12	0.06	2.17	3.6	0.15	0.05

ASWD: Available soil water depletion; PH: Plant height; CD: Canopy diameter

Automated drip irrigation in banana at ICAR-IIWM Research Farm

Eco-friendly Wastewater Treatment for Re-use in Agri-sectors: Lab to Land Initiative (Theme-IV)

Investigators : S. Raychaudhuri, M. Raychaudhuri, S.K. Rautaray, S.K. Jena and Rachana Dubey

Collaborating Institute : ICAR-IARI (WTC), New Delhi

In-situ wastewater treatment system was installed in a drain adjacent to the ICAR-IIWM gate at Chandrasekharpur, Bhubaneswar. It has components with removable or adjustable structure with no use of non-renewable energy source. The testing is being carried out with the aim to up-scale the in-situ system. The drain dimension was 18 m long, 1.7 m wide and 1 m depth. Three gabions with dimensions of 1.7 m wide, 1 m height and 0.7 m thick were placed perpendicular to the wastewater flow in the drain at 3 m apart. The three gabions were made of three different filtration materials of 20 cm thickness sandwiched between two layers of stones (25 cm thick). The stones were stacked in cages made of cross linked diamond shaped wire having multiple dimensions to make the spillway in the gabion in case of high wastewater discharge or rainfall. A bar screen was placed between the 1st gabion and wastewater discharge point into the drain to arrest big floating materials like plastic bottles, plastic sheets/bags, coconut shells, stones etc. The system was installed without spillway in the month of May 2017. This wastewater treatments was found to reduce suspended solids by 60% and BOD by 45%.

The heavy metals reductions were 66% for chromium (Fig. 33) and 75% for both nickel and cadmium. No significant stagnation of wastewater in the upstream was also observed during summer months. With spillway, the reductions in BOD, suspended solids, chromium, nickel and cadmium were 37, 34, 53, 42 and 47%, respectively. The microbial reductions were 5-Log and 3-Log in without and with spillway respectively.

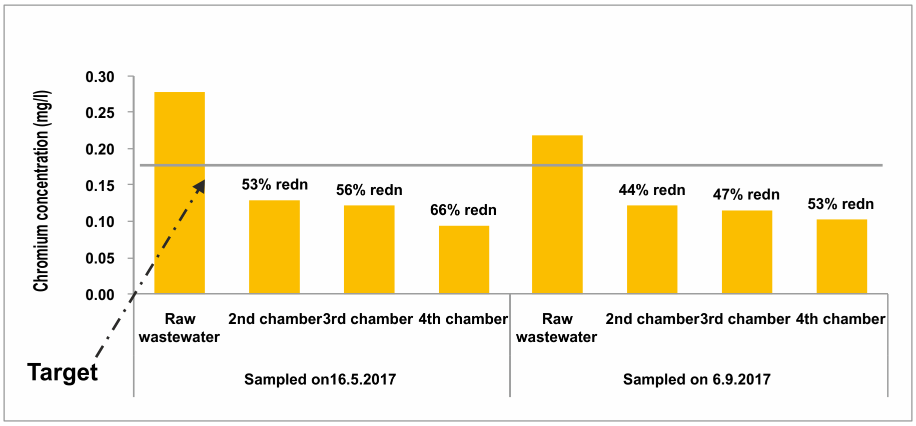


Fig. 33. Chromium concentration in different chambers of wastewater treatment system

The treated wastewater is in use to irrigate adjacent lawns through sprinkler. Visually, the treated wastewater was much less turbid and less smelly. During rainy season, without spillway caused flooding in the upstream; however, there was no significant stagnation of water in the upstream in with-spillway system. The drain receives excess silt along with waste water. The silt deposition before the bar screen is an issue which calls for a silt removal system. The impact of treated wastewater was studied in pots in comparison to untreated wastewater. The available NPK and organic C of soils with untreated wastewater were found 14, 22, 49 and 11 percent higher than that with treated wastewater. The EC and chromium concentration were also higher by 23 and 63% over soils with treated wastewater.

The installed treatment system

Water Budgeting and Enhancing Water Productivity by Multiple Use of Water in Different Aquaculture Production Systems (Theme-V)

Investigators : R.K. Mohanty, P. Panigrahi, P. Sahu and S.K. Ambast

Collaborating Institutes : ICAR-CIFA, Bhubaneswar

Under CRP on Water (Theme-5), an IFS model has been developed. A pond of 700 m^2 had been stocked with IMCs @ 5000 fingerlings ha^{-1}. On-dyke horticulture with 120 plants of banana (var. G-9) in two rows and 60 papaya plants (var. Red Lady) in single row planting were carried out. The land adjacent to the pond was 0.3 ha, on which *kharif* rice was grown with grain yield of 3.42 t ha^{-1}, followed by green gram (0.98 t ha^{-1}) while, 0.1 ha area was also under ladies finger (17.1 t ha^{-1}), followed by pumpkin (26.3 t ha^{-1}). White Pekins breed of ducks had also been introduced as an integrated component. Life-saving irrigation (780 m^3 out of 1810 m^3) to on-dyke crops & agriculture crops was provided using the pond water. Net income was ₹79,617 ha^{-1} in 240 days while, net water productivity and B:C ratio was ₹ 16.2 m^{-3} and 2.6, respectively. In another experiment, grow-out production of IMC was assessed with different production levels through varying cropping pattern and water use. It was found that 'multiple stocking and multiple harvesting' (MSMH) is highly promising and productive followed by inter-crop method of carp farming. The estimated yield and consumptive water use index in MSMH were 4.1 t ha^{-1} and 1.8 m^3 kg^{-1} fish, respectively.

Banana and papaya on dyke of pond

Institutional and Market Innovations Governing Sustainable Use of Agriculture Water (Theme-VIII)

Investigators : P. Nanda and A.K. Nayak

Collaborating Institutes : UAS, Bangalore; NLSIU, Bangalore

The farm household survey in the districts of Balasore, Bhadrakh and Khurda carried out for the pump owners, sellers and buyers. The Water User Associations were studied with respect to their efficacies in managing water and group dynamics in terms of resolution of conflicts, operation and maintenance of the irrigation system and collection of the membership fee and multiple activities taken up for sustenance of the WUAs. A sample of 121 households was drawn randomly from all selected blocks (Baliapal, Bhogarai in Balasore district;Basudevpur in Bhadrakh; and Balianta and Balipatana blocks in Khurda district having good groundwater draft in the state. The sample was post stratified into three categories i.e. small, medium and large using Cumulative Square Root Frequency Method on the basis of operational land holdings. Data was collected from different households under different size class categories. The structure of water market prevailing in the districts in terms of different categories of water users is presented in table 16. It shows that buyers and self-users + sellers are the dominant categories of participant in the water market. While majority of the small and marginal farmers (51.02% of marginal farmers and 38.03% of small farmers) are found to be buyers, most of the large farmers (64%) belong to self-users and self-users + sellers category. It explicitly illustrates that the number of water buyers decreased as the size of farm increased, while the number of sellers increased with the size of the farm. The water markets in the study area are informal, based on informal contract agreements. Water charge realized is based on area approach where the amount of water charged is based on the amount of land irrigated and the type of crops to be irrigated irrespective of the season. The mode of transactions in the market is found to be both cash and kind depending on situations. The pattern of water charge realized in the district is presented in table 17.

Table 17. Nature of transactions across categories of users

Mode of Transaction	Percentage of farmers buying water	Percentage of farmers experiencing price discrimination
Cash	27.87	4.96
Kind	6.57	
Both	65.57	

Table 16. Distribution of sampled farmers as per category of water trading

Farm category	Categories of water users					Total
	Self-user	Self-user + Sellers	Self-users + Sellers + Buyers	Self-users + Buyers	Buyers	
Marginal	8 (16.33)	14 (28.57)	0 (0)	2 (4.08)	25 (51.02)	49 (100)
Small	10 (21.27)	12 (25.53)	4 (8.51)	3 (6.38)	18 (38.3)	47 (100)
Large	7 (28)	9 (36)	5 (20)	1 (4)	3 (12)	25 (100)
Total	25 (20.7)	35 (28.92)	9 (7.43)	6 (4.95)	46 (38.01)	121(100)

The figures in parentheses represent percentage of total in each row

Weather Report of Research Farm

The weekly rainfall and open pan evaporation data was recorded during 2017-18 at ICAR-IIWM Research Farm, Deras Mendhasal, Khurda and were analysed, presented in presented Fig. 34. The total rainfall between April 2, 2017 and April 1, 2018 was 1383.1 mm (Annual rainfall was also same) and standard meteorological week (SMW) 35 received the highest rainfall of 142 mm. Total evaporation was 1309.3 mm and highest evaporation was observed during SMW 18 (57.1 mm) and thereafter it declined during monsoon period.

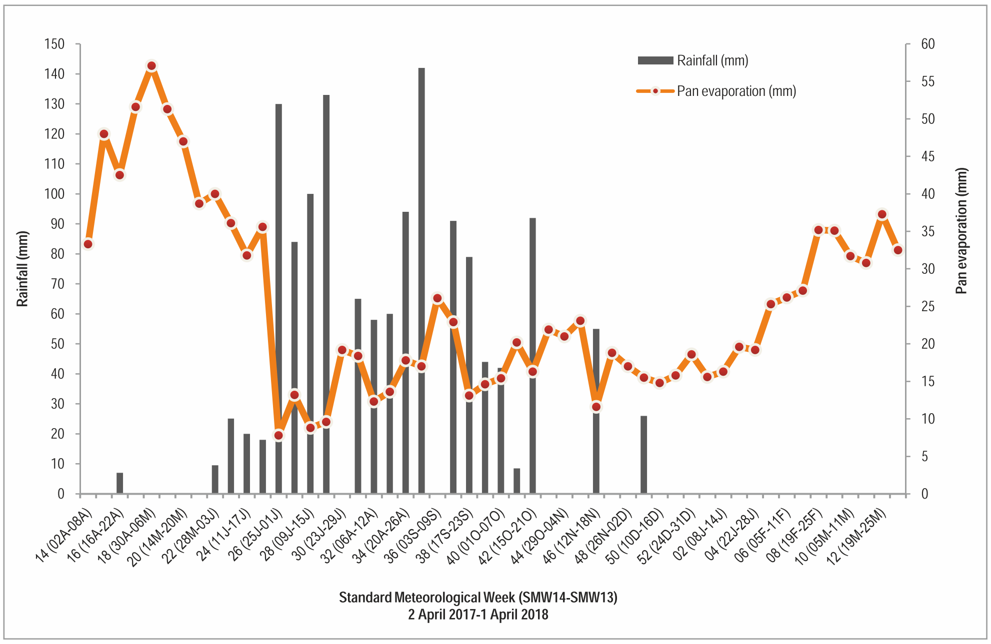


Fig. 34. Weekly rainfall and pan evaporation during April 2017-March 2018 (SMW14-SMW13)

PUBLICATIONS 2017-18

Publications 2017-18

Peer reviewed articles

Adhikari, P., Araya, H., Aruna, G., Balamatti, A., Banerjee, S., Baskaran, P., Barah, B.C., Behera, D., Berhe, T., Boruah, P., Dhar, S., Edwards, S., Fulford, M., Gujja, B., Ibrahim, H., Kabir, H., Kassam, A., Khadka, R.B., Koma, Y.S., Natarajan, U.S., Perez, R., Sen, D., Sharif, A., Singh, G., Styger, E., Thakur, A.K., Tiwari, A., Uphoff, N., and Verma, A. 2017. System of crop intensification for more productive, resource-conserving, climate-resilient, and sustainable agriculture: experience with diverse crops in varying agro-ecologies. *International Journal of Agricultural Sustainability*, 16 (1): 1-28.

Bhelawe, S., Das, G.K., Manikandan, N. and Chaudhary, J.L. 2017. Trends of moisture regime and intensity of droughts in three agro climatic zone of Chattisgarh state. *Journal of Agrometeorology,* 19 (Spl. Issue): 103-108.

Bhuarya, S.K., Manikandan, N., Chaudhary, J.L. and Khalkho, D. 2017. Temperature trend analysis of four stations of Chhattisgarh state. *Journal of Agrometeorology,* 19 (4): 379-380.

Biswas, S.S., Singhal, S.K., Biswas, D.R., Singh, R.D., Roy, T., Sarkar, A., Ghosh, A. and Das, D. 2017. Synchronization of N supply with demand by wheat using sewage sludge as organic amendment in an Inceptisol. *Journal of the Indian Society of Soil Science,* 65(3): 264-273.

Chaudhary, R.S., Somasundaram, J., Mandal, K.G. and Hati, K.M. 2018. Enhancing water and phosphorus use efficiency through moisture conservation practices and optimum phosphorus application in rainfed maize-chickpea system in vertisols of central India*. Agricultural Research,* DOI: 10.1007/s40003-018-0316-8.

Das, M., Verma, O.P., Patri, D. and Sethi, R. 2017. Scope of soil organic carbon sequestration through agro-based industrial wastewater use in different soil types dominated in eastern India. *International Journal of Environment and Waste Management*, 20 (2): 155-170.

Das, M., Verma, O.P., Swain, P., Sinhababu, D.P. and Sethi, R. 2017. Impact of brackish water shrimp farming at the interface of rice growing areas and the prospects for improvement in coastal India. *Journal of Coastal Conservation*, 21 (6): 981-992.

Deb Roy, P., Lakshman, K., Narwal, R.P., Malik, R.S. and Saha, S. 2017 Green gram (*Vigna radiata* L.) productivity and grain quality enrichment through zinc fertilization. *International Journal of Current Microbiology and Applied Science,* 6(6): 643-648.

Dubey R., Pathak, H., Pal, M., Chakrabarti, B. and Harit, R.C. 2016. Effect of sowing date, cultivars and irrigation scheduling on physiological parameters of wheat (*Triticum aestivum*) with climate change adaptation in perspective. *Current Advances in Agricultural Sciences*, 8(2): 135-138.

Ghosh, A., Bhattacharyya, R., Dwivedi, B.S., Biswas, D.R., Meena, M.C., Sarkar, A., Agarwal, B.K., Mahapatra, P., Shahi, D.K., Agnihotri, R. and Salwani, R. 2018. Depth dynamics of soil N contents and natural abundances of ^{15}N after 43 years of long-term fertilization and liming in sub-tropical Alfisol. *Archives of Agronomy and Soil Science*. DOI 10.1080/03650340.2018.1428310.

Kar, G., Kumar, A., Panigrahi, S., Dixit, P.R., Sahoo, H.N. 2017. Particle size distribution, soil organic carbon stock and water retention properties of some upland use system of Odisha and assessing their interrelationship. *Journal of the Indian Society of Soil Science,* 65 (1): 48-53.

Mandal, U., Panda, R.K., Mishra, P.K., Alam, N.M. and Kar, G. 2017. Conceptualization of community-based integrated farming system model design with multi-objective optimization management. *Current Science*, 112 (11): 1234-1242.

Manikandan, N., Kar, G. and Roy Chowdhury, S. 2017. Impact of El-Niño event on seasonal and annual rainfall over Odisha state. *Journal of Indian Society of Coastal Agricultural Research, 35(2): 48-52.*

Mohanty, B., Banafar, K.N.S., Dash, H.K. and Gauraha A.K. 2017. Livestock for livelihood: The changing scenario in the 1999-Super cyclone affected Ersama block of Odisha. *Trends in Biosciences,* 10 (30): 6254-6258.

Mohanty, R.K. and Mohapatra, A. 2017. Cyclic feed restriction on growth compensation of *Penaeus monodon* (Fabricius): science meets practice. *Indian Journal of Geo-Marine Sciences (Indian Journal of Marine Sciences)*, 46 (10):2008-2016.

Mohanty, R.K., Ambast, S.K., Panigrahi, P., Mandal, K.G. 2018. Water quality suitability and water use indices: Useful management tools in coastal aquaculture of *Litopenaeus vannamei*. *Aquaculture,* 485: 210-219.

Mohanty, R.K., Mishra, A., Ambast, S. K., Mandal, K.G., Panda, D.K., Panigrahi, P. 2017. Effects of various shrimp (*Penaeus monodon*) densities on their growth, water and sediment quality, and water budget. *Aquaculture International,* 25: 2161–2176.

Mohanty, R.K., Mishra, A., Mandal, K.G., Panigrahi, P. and Ambast, S.K. 2017. Water use in carp polyculture: Effects on rearing environment and water productivity. *Journal of Indian Society of Coastal Agricultural Research,* 35(1): 68-75.

Mohanty, S., Rautaray, S.K. and Panda D.K. 2018. Effect of fertilizer levels and supplementary irrigation on late maturing transplanted paddy under rainfed medium land situations. *Oryza*, 55(1): 179-184.

Mondal, B, Singh, Alka, Singh, S.D., Kalra, B.S., Samal, P., Sinha, M.K., Ramajayam, D. and Kumar, S. 2018. Augmentation of water resources potential and cropping intensification through watershed programs. *Water Environment Research*, 90: 101-109. doi:10.2175/106143017X14902968254700

Nanda, P. and Ghosh, S. 2017. Adaptation strategies under climate induced natural disasters in coastal areas of Odisha. *Journal of Indian Society of Coastal Agricultural Research,* 35(1): 82-89.

Nayak, A.K., Nanda, P., Srivastava, R.C., Das, M., Ghosh, S., Kumar, A., Ambast, S.K., Patil, R.G., Khodke, U.M. and Yadav, B.S. 2017. Application of ICT in development of agriculture water management portal. *Journal of the Indian Society of Coastal Agricultural Research*, 35(1): 96-98.

Padua Sheldon, Chattopadhyay, T., Bandyopadhyay, S., Ramchandran, S., Jena, R.K., Ray, P., Deb Roy, P., Baruah, U., Sah, K.D., Singh, S.K., and Ray, S.K. 2018. A simplified soil nutrient information system study from the North East region of India. *Current Science,* 114(6): 1241-1249.

Panda, D.K., Das, P. and Ambast, S.K. 2017. Integrated approach for improving water productivity in groundwater exploited areas of coastal Odisha. *Journal of Indian Society of Coastal Agricultural Research, 35(2): 30-34.*

Panigrahi, P. and Srivastava, A.K. 2017. Water and nutrient management effects on water use and yield of drip irrigated citrus in vertisol under a sub-humid region. *Journal of Integrative Agriculture*, 16 (5): 1184-1194.

Pradhan, S., Bandyopadhyay, K.K., Chopra, U.K., Krishnan, P., Jain, A.K., Singh, R., Chand, I. 2017. Yield, grain protein content and input use efficiency in wheat as influenced by irrigation and nitrogen levels in a semi-arid region. *Journal of Indian Society of Soil Science,* 65(4): 410-422.

Pradhan, S., Sehgal, V.K., Bandyopadhayay, K.K., Sahoo, R.N., Panigrahi, P., Parihar, C.M. and Jat, S.L. 2018. Comparison of vegetation indices from two ground based sensors. *Journal of Indian Society of Remote Sensing*, 46(2): 321-326.

Pradhan, S., Sehgal, V.K., Sahoo, R.N., Bandyopadhyay, K.K. and Singh, R. 2018. Yield, water and radiation use efficiency of wheat as influenced by irrigation levels in a semi-arid environment. *Journal of Agrometeorology,* 20: 31-36.

Raina, A.K, Bharti V. and Nanda, P. 2017. Performance evaluation for up scaling water productivity of wheat in Ranbir canal command of Jammu. *Environment & Ecology,* 35 (2D): 1526-1528.

Raina, A.K., Nanda, P. and Singh, J. 2018. Performance evaluation of Tawi-lift command. *Environment & Ecology,* 36 (1): 163-165.

Raut, S., Kar, G. and Sahoo, N. 2016. Study of waterlogging and drainage in relation to soil in coastal Odisha using remote sensing and GIS. *Journal of the Indian Society of Coastal Agricultural Research*, 34(1): 156-57.

Raychaudhuri, S., Raychaudhuri, M., Rautaray, S.K., Parida, S. and Kumar, A. 2017. Urban wastewater – A potential irrigation source for summer paddy (*Oryza sativa* L.) in India. *International Journal of Agriculture Innovations and Research*, 5(6): 986-995.

Roy Chowdhury S., Brahmanand P.S., Chakraborty, S., Kumar, A. and Ambast, S.K. 2017. Performance assessment of non-food commercial crop cat tail (*Typha* sp.) and leaf quality at different nitrogen level under waterlogged condition. *Journal of Interacademicia,* 21:11-18.

Roy Chowdhury, S., Brahmanand, P.S., Manikandan, N. and Ambast, S.K. 2017. Effect of N application on its utilization and gaseous exchange in cat tail (*Typha elephantina*) under waterlogged condition. *Indian Journal of Plant Physiology*, 22 (2): 263-266.

Roy, T., Biswas, D.R., Datta, S.C. and Sarkar, A. 2018. Phosphorus release from rock phosphate as influenced by organic acid loaded nano clay polymer composites in an Alfisol. *Proceeding of National Academy of Sciences, India Section B: Biological Sciences*, 88(1): 121–132.

Roy, T., Biswas, D.R., Datta, S.C., Sarkar, A. and Biswas, S.S. 2018. Citric acid loaded nano clay polymer composite for solubilization of Indian rock phosphates: a step towards sustainable and phosphorus secure future. *Archives of Agronomy and Soil Science,* doi.org/10.1080/03650340.2018.1444275.

Sarkar, A., Biswas, D.R., Datta, S.C., Manjaiah, K.M. and Roy, T. 2017. Release of phosphorus from laboratory made coated phosphatic fertilizers in soil under different temperature and moisture regime. *Proceeding of National Academy of Sciences, India Section B: Biological Sciences,* 87(4): 1299-1308.

Sarkar, A., Biswas, D.R., Datta, S.C., Roy, T., Moharana, P.C., Biswas, S.S. and Ghosh, A. 2018. Polymer coated novel controlled release rock phosphate formulations for improving phosphorus use efficiency by wheat in an inceptisol. *Soil and Tillage Research,* 180: 48-62.

Sethi, R.R., Srivastava, R.C., Behera, A., Das, M., Brahmanand, P.S. and Tripathy, J.K. 2017. Runoff estimation and water management options for coastal Odisha. *Indian Journal of Ecology, 44*(3): 451-455.

Sinha, H.K., Chaudhary, J.L., Manikandan, N. and Bhuarya, S.K. 2017. Spatial analysis of meteorological drought in Chhattisgarh state. *Indian Journal of Dryland Agriculture Research & Development,* 32(2): 94-97.

Sinha, M.K., Thombare, N.N., Mondal, B., Meena, M.S. and Kumar, P. 2017. Analysis of foot and mouth disease in dairy animals: an assessment of cost and loss from sample farmers. *Indian Journal of Animal Research,* doi:10.18805/ijar.B-3392.

Stoop, W.A., Sabarmatee, Pushpalatha, S., Ravindra, A., Sen, D., Prasad, S.C. and Thakur, A.K. 2017. Opportunities for ecological intensification: lessons and insights from the System of rice/crop intensification – their implications for agricultural research and development approaches. *CAB Reviews,* 12, No. 036: 1-19. doi: 10.1079/PAVSNNR201712036

Unjan, D., Sastri, A.S.R.A.S., Manikandan, N., Singh, R. and Diwan, U. 2017. Rainfall analysis for suitability of rainfed rice cultivation in Chhattisgarh state during pre- and post-global warming period. *International Journal of Current Microbiology and Applied Sciences*, 6(6): 338-350.

Popular articles

Dev, R., Sharma, G.K., Dubey, R. and Devidayal 2017. Date palm: Post-harvest value addition for better income. *Kisan Gyan*, 10-18.

Pradhan, S., Sehgal, V.K., Bandyopadhyay, K.K., Mukherjee, J., Das, D.K. and Dhakar, R.K. 2017. Trend analysis of weather parameters and climatic water balance at New Delhi. *Mausam,* 68(2): 375-382.

Rautaray, S.K., Mishra, A., Sinha, M.K., Mohanty, R.K., Behera, M.S. and Ambast, S.K. 2017. Energy efficiency and economics of transplanted rice under integrated nutrient management in a rainfed medium land. *Bharatiya Hindi Krishi Anusandhan Patrika,* 32(1): 8-11.

Sethi, R.R., Kaledhonkar, M.J., Das, M., Srivastava, S.K., Srivastava, R.C., Verma, O.P. and Kumar, A. 2016. Odisha ke tatiya Bhubhag mein bhujal pumping vikalpa. *Krishika Shoudh Patrika,* 5(1): 28-34.

Sinha, M.K., Thombare, N.N. and Mondal, B. 2017. A cost-benefit analysis of vaccination against foot and mouth disease of bovines. *Bharatiya Krishi Anusandhan Patrika, 32 (1)*: 35-38.

Books / Bulletins / Training manuals

Brahmanand, P.S., Ambast, S.K., Roy Chowdhury, S., Jena, S.K., Bhatt, B.P., Amarnath, G. and Sikka, A.K. 2017. Post-flood management options for agricultural sector in selected districts of Bihar and Odisha. ICAR-IIWM Extension Bulletin No. 01/2017. ICAR-Indian Institute of Water Management, Bhubaneswar. 8p.

Jena, S.K., Mishra, A. and Ambast, S.K. 2017. Training manual on 'Hydrological Study and Monitoring of Watersheds'. ICAR-Indian Institute of Water Management, Bhubaneswar, Odisha, India, 158p.

Kar, G., Verma, O.P. and Ambast, S.K. 2017. *Bharat me jal evm khadya suraksha ke liye jalvayu parivartan ke anukul krishi* (In Hindi). ICAR-Indian Institute of Water Management, Bhubaneswar, Odisha, 158p.

Mohanty, S., Panigrahi, P. and Ambast, S.K. 2017. Training manual on 'Improving Water Productivity in Rainfed Agriculture'. ICAR-Indian Institute of Water Management, Bhubaneswar, Odisha, India, 96p.

Panda, R.K., Sethi, R.R. and Ambast, S.K. 2017. Training manual on 'Concepts of Standard Design, Layout of Different Structural Measures in Watersheds'. ICAR-Indian Institute of Water Management, Bhubaneswar, Odisha, India, 74p.

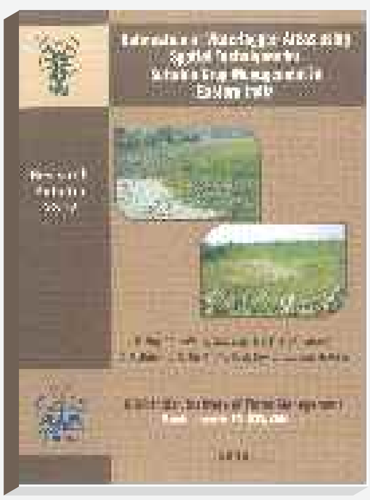
Raychaudhuri, M., Raychaudhuri, S. and Dubey, R. 2018. Training manual on 'Improving Land and Water Productivity – A Key to Double Framers' Income'. ICAR-Indian Institute of Water Management, Bhubaneswar, Odisha, India, 174p.

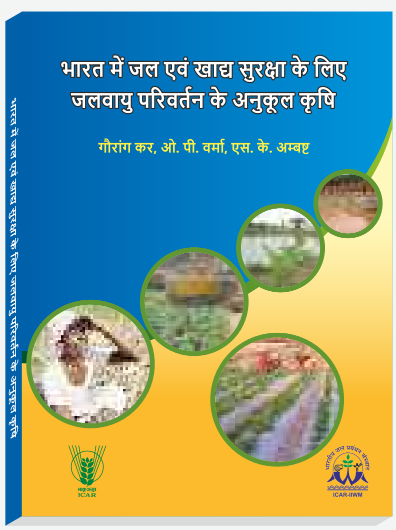
Roy Chowdhury, S., Nayak, A.K., Brahmanand, P.S., Mohanty, R.K., Chakraborty, S., Kumar, A. and Ambast, S.K. 2018. Delineation of waterlogged areas using spatial techniques for suitable crop management in Eastern India. ICAR-IIWM Research Bulletin 79. ICAR-Indian Institute of Water Management, Bhubaneswar, Odisha, India, 44p.

Sinha, M.K., Dubey, R., Verma, O.P. and Ambast, S.K. 2017. *Doguni kisani aay evm surakshit aajivika ke liye jal sarankshan evm daksh sinchai pranali* (In Hindi). ICAR-Indian Institute of Water Management, Bhubaneswar-751023, Odisha, India, 79p.

Sinha, M.K., Manikandan, N., Partho Deb Ray and Ambast, S.K. 2018. *Phasal utpadan evm khadya suraksha ke liye krishi jal prabandhan* (In Hindi). ICAR-Indian Institute of Water Management, Bhubaneswar-751023, Odisha, India, 112p.

Sinha, M.K., Pradhan, S., Sethi, D. and Ambast, S.K. 2018. *Doguni kisani Aaya ke liye sinchai jal prabandhan* (In Hindi). ICAR- Indian Institute of Water Management, Bhubaneswar, Odisha, India, 88p.





Research Projects

IN-HOUSE PROJECTS (2017-18)

Sl. No.	Project Code	Project Title	PI Name
1.	IIWM/15/168	Water and nutrient self-reliant farming system for rainfed area under high rainfall zone	Dr. S.K. Rautaray
2.	IIWM/15/169	Drainage planning of eastern coast delta using geoinformatics	Dr. S.K. Jena
3.	IIWM/15/170	Impact assessment study of using industrial wastewater on sunflower (*Helianthus annus* L.) and mustard (*Brassica nigra* L.) grown in peri-industrial area of Angul, Odisha	Dr. R. Dubey
4.	IIWM/15/171	Developing the process for remediation of chromium from polluted water sources	Dr. M. Das
5.	IIWM/15/172	Evaluation of feasibility of enhancing irrigation efficiency in canal command through improved surface and pressurized irrigation methods by adding adjunct service reservoir and open dug well	Dr. R.K. Panda
6.	IIWM/15/173	Inter-regional virtual water trade in India through agro-based products	Dr. G. Kar
7.	IIWM/15/174	Enhancing water productivity through water management in transplanted and aerobic rice in canal command area	Dr. K.G. Mandal
8.	IIWM/15/175	Density dependent water use in coastal aquaculture of *Litopenaeus vannamei*	Dr. R.K. Mohanty
9.	IIWM/15/176	Enhancing water productivity through intensive horticultural system in degraded land	Mrs. P. Sahu / Dr. S. Pradhan
10.	IIWM/16/177	Benchmarking of public irrigation schemes for improving performance of irrigated agriculture	Dr. A. Mishra
11.	IIWM/16/178	Socio-economic and environmental linkages of groundwater irrigation in selected aquifers of India	Dr. D. K. Panda
12.	IIWM/16/179	Water Use Efficient practices for successful establishment and yield enhancement of pulse crops in rice based cropping system in seasonal waterlogged ecosystem	Dr. P.S. Brahmanand
13.	IIWM/16/180	Design and field evaluation of groundwater recharge structures for hard rock region	Dr. R.R. Sethi
14.	IIWM/16/181	Development of web-based expert system on agricultural water management	Dr. A.K. Nayak
15.	IIWM/16/182	Enhancing yield and water productivity of Rice-fallow areas of eastern India through Super Absorbent Polymers (SAP)	Dr. S. Pradhan
16.	IIWM/17/183	Development and evaluation of mini pan evaporimeter for on-farm irrigation scheduling	Mr. N. Manikandan
17.	IIWM/17/184	Evaluation of land shaping options for increasing farm income in coastal waterlogged area	Dr. S. Roy Chowdhury
18.	IIWM/17/185	Assessment of groundwater contamination due to excess fertilizer and pesticide uses and its management in lower Godavari basin	Dr. A. Sarkar
19.	IIWM/17/186	Smart water management system in agriculture	Dr. D. Sethi
20.	IIWM/17/187	Socio-economic evaluation of water related interventions under MNREGA	Dr. H.K. Dash
21.	Exploratory trial	Evaluating rice ratooning under different management practices to enhance crop and water productivity	Dr. A.K. Thakur

EXTERNALLY FUNDED (2017-18)

Title	Budget (Rs. in lakh)	Duration	PC / NO / PI / CCPI	Sponsored by
All India Co-ordinated Research Project on Irrigation Water Management	7484.64	2017-20	Dr. S.K. Ambast, PC	ICAR, New Delhi
Agri-Consortia Research Platform on Water	1302.19	2017-20	Dr. S.K. Ambast, LCPC Dr. P. Panigrahi, Dy LCPC	ICAR, New Delhi
I. Development and Management of Integrated Water Resources in Different Agro-ecological regions of India	-	-	Dr. S.K. Jena	Agri-Consortia Research Platform on Water, ICAR, New Delhi
II. Evaluation of Irrigation System and Improvement Strategy for Higher Water productivity in Canal Commands	-	-	Dr. R.K. Panda	Agri-Consortia Research Platform on Water, ICAR, New Delhi
III. Automatic Irrigation and Fertigation in Drip-irrigated Banana under Efficient Water Management in Horticultural Crops	-	-	Dr. P. Panigrahi	Agri-Consortia Research Platform on Water, ICAR, New Delhi
IV. Eco-friendly Wastewater Treatment for Re-use in Agri-sectors: Lab to Land Initiative	-	-	Dr. S. Raychaudhuri	Agri-Consortia Research Platform on Water, ICAR, New Delhi
V. Water Budgeting and Enhancing Water Productivity by Multiple Use of Water in Different Aquaculture Production Systems	-	-	Dr. R.K. Mohanty	Agri-Consortia Research Platform on Water, ICAR, New Delhi
VI. Institutional and Marketing Innovations Governing Use of Agriculture Water	-	-	Dr. P. Nanda	Agri-Consortia Research Platform on Water, ICAR, New Delhi
National Initiative for Climate Resilient Agriculture (NICRA)	600.00	2012-2020	Dr. G. Kar	ICAR, New Delhi
Index Based Flood Insurance (IBFI) and Post-Disaster Management to promote agriculture resilience in selected states in India	171.71 (USD268305)	2017-2020	Dr. S.K. Ambast, Nodal Officer; Dr. P.S. Brahmanand (PI)	International Water Management Institute (IWMI), Colombo
Enhancing Economic Water Productivity in Irrigation Canal Commands	112.32 (USD175500)	2017-2020	Dr. S.K. Ambast, Nodal Officer; Dr. R.K. Panda (PI)	International Water Management Institute (IWMI), Colombo
Revival of Village Ponds through scientific intervention	28.82	2017-2019	Dr. S.K. Jena	DST, Ministry of Science & Technology, New Delhi
Development of biological filter for safe wastewater irrigation exploiting microbial bioremediation trait	138.684	2017-2020	Dr. S. Raychaudhuri	National Agricultural Science Fund, ICAR
Efficient Groundwater Management for Enhancing Adaptive Capacity to Climate Change in Sugarcane Based Farming System in Muzaffarnagar district, Uttar Pradesh	459.00	2015-2019	Dr. A. Mishra	Ministry of Agriculture, Govt. of India
Enhancing Land and Water Productivity through Integrated Farming System (Tribal Sub Plan Project)	20.00	2014-2018	Dr. R.K. Panda	ICAR, New Delhi
Enhancing Water and Livelihoods Security and Improving Water Productivity in Tribal Dominated Paddy Fallow Rainfed Agro Ecosystem of Odisha (Farmer's First Program)	18.00	2016-17	Dr. S.K. Ambast, Nodal Officer; Dr. P. Nanda (PI)	ICAR, New Delhi

COLLABORATIVE

Title	Budget (Rs. in lakh)	Duration	Co-PI	Sponsored by
Assessment of Soil Fertility and Preparation of Soil Fertility Maps for Various Agro-Ecosystems of Odisha (with ICAR-CTCRI Regional Center, Bhubaneswar)	84.53	2014-2018	Dr. M. Das	RKVY, Office of the Director of Horticulture, Odisha

CONSULTANCY

Title	Budget (Rs. in lakh)	Duration	Course Director/ Convener/ Coordinators	Sponsored by
Advanced Capacity Building Programme with special emphasis on Soil & Water Conservation activities in Watersheds for Field Functionaries of the Directorate of Soil and Water Conservation and Watershed Development, Govt. of Odisha under PMKSY (10 nos. of training programmes)	59.00	August, 2017 – January, 2018	Course Director: Dr. S.K. Ambast Course Coordinators: 1. Dr. A. Mishra & Dr. S.K. Jena 2. Dr. R.K. Panda & Dr. R.R. Sethi 3. Dr. S. Mohanty & Dr. P. Panigrahi	Directorate of Soil Conservation & Watershed Development, Govt. of Odisha, Bhubaneswar
Analysis of soil samples (bulk density and soil texture) in five districts of Odisha	1.593	2017-18	Dr. G. Kar	World Vegetable Centre-ICRISAT, Andhra Pradesh
Interstate Farmers Training Program on 'Water Conservation and Efficient Irrigation System for Enhancing Income and Livelihood' under PMKSY	0.87	November 27-30, 2017	Convener: Dr. S.K. Ambast Course Coordinators: Dr. M.K. Sinha Dr. R. Dubey Dr. O.P. Verma	ATMA, Samastipur, Bihar
Interstate Farmers Training Program on 'Irrigation Water Management towards doubling farmers' income' under PMKSY	0.937	January 9-11, 2018	Convener: Dr. S.K. Ambast Course Coordinators: Dr. M.K. Sinha Dr. S. Pradhan Dr. D. Sethi	ATMA, Muzaffarpur, Bihar
Interstate Farmers Training Program on 'Agricultural Water Management for Crop Production and Food Security' under PMKSY	1.583	February 12-16, 2018	Convener: Dr. S.K. Ambast Course Coordinators: Dr. M.K. Sinha Mr. N. Manikandan Mr. P. Deb Roy	ATMA, Madhubani, Bihar

AWARDS, HONOURS, RECOGNITIONS

Awards, Honours, Recognitions

- ICAR-Indian Institute of Water Management recognized as ISO 9001:2015 certified research institute in the field of Agricultural Water Management.


CERTIFICATE

TÜV NORD

Management system as per

ISO 9001 : 2015

ICAR-INDIAN INSTITUTE OF WATER MANAGEMENT
(Indian Council of Agricultural Research)
Opp. Rail Vihar, Chandrasekharpur,
Bhubaneswar – 751 023, Odisha,
India

Research in the Field of Agricultural Water Management


Dr. P.S. Brahmanand, Principal Scientist awarded with 'UtkalDiwas Samman-2017'

- Dr. G. Kar, Principal Scientist recognized as 'Fellow of Indian Society of Soil Science' during 82nd ISSS convention at AMITY University, Kolkata on December 11, 2017.

Dr. G. Kar, Principal Scientist awarded with 'Fellow of ISSS'

- Dr. G. Kar, Principal Scientist has been recognized as 'Fellow of the West Bengal Academy of Science and Technology (Section X: Agriculture and Forestry)' in the year 2017 for his notable contributions in 'Agro-climatology'.
- Dr. S. Pradhan, Scientist received 'Dr. S. Venkataraman Young Scientist Award 2017' from Association of Agro-meteorologist, Anand, Gujarat.
- Dr. K.G. Mandal, Principal Scientist has been selected Member, the National Academy of Sciences, India in the year 2017.
- Dr. P.K. Panda, Dr. R.K. Mohanty, Dr. P. Panigrahi and Dr. A. Kumar received 'Best Poster Award' at 3rd ARRW International Symposium held at ICAR-NRRI, Cuttack during February, 6-9, 2018 for the paper entitled 'Development of Runoff recycling model for climate resilience and profit enhancement of rainfed rice'.

- Dr. S.K. Jena, Principal Scientist received 'Appreciation Award' from IRMRA, Thane for significant contribution in developing rubber dam technology.
- Dr. P.S. Brahmanand, Principal Scientist received appreciation letter from Director, National Water Mission, Ministry of Water Resources, River Development & Ganga Rejuvenation, GoI for contribution towards technical guidance and preparation of template for State Specific Action Plan on Water.
- Drs. S.K. Rautaray, A. Mishra, M.K. Sinha, R.K. Mohanty, M.S. Behera, and S.K. Ambast received '*Krishi Vigyan Gaurav, 2017*' awarded by *Bharatiya Krishi Anusandhan Samiti* and *Krishi Anusandhan Sanchar Kendra*, Karnal.
- Drs. M.K. Sinha, N.N. Thombare and B. Mondal received '*Krishi Vigyan Gaurav, 2017*' awarded by *Bharatiya Krishi Anusandhan Samiti* and *Krishi Anusandhan Sanchar Kendra*, Karnal.
- Dr. P.S. Brahmanand, Principal Scientist has been awarded with '*Swachhata Puraskar-2017*' by ICAR-Indian Institute of Water Management, Bhubaneswar on the occasion of Gandhi Jayanti for his overall initiative, dedication and leadership to ensure successful implementation of '*Swachh Bharat Abhiyan*'.
- Dr. M. Das, Principal Scientist, has been nominated by ICAR as member, Institute Management Committee (IMC) of ICAR-IISS, Bhopal.
- Dr. S.K. Jena, Principal Scientist, has been nominated by ICAR as member, Institute Management Committee (IMC) of ICAR-Indian Institute of Soil & Water Conservation, Dehradun and ICAR Research Complex for Eastern Region, Patna, Bihar.
- Dr. R.K. Mohanty, Principal Scientist, has been nominated by ICAR as member, Institute Management Committee (IMC) of ICAR-NRC on Integrated Farming, Motihari, Bihar.
- Dr. S. Pradhan, Scientist has been elected as Assistant Secretary to Indian Society of Agrophysics.
- Drs. K.G. Mandal and A.K. Thakur, Principal Scientists became Associate Editors of 'Agronomy Journal', published by American Society of Agronomy (ASA), USA and 'Irrigation Science', published by Springer, respectively.
- Drs. S. Roy Chowdhury and Dr. A.K. Thakur, Principal Scientists have been selected as editor for Indian Journal of Plant Physiology (Springer), ISPP, New Delhi.
- Dr. M. Raychaudhuri, Principal Scientist appointed as recorder for the section-'Agriculture and Forestry Sciences' for 2018-2020 by Indian Science Congress Association.

- Dr. P.S. Brahmanand, Principal Scientist has been elected as Executive Memberof Indian Society of Water Management (Odisha Chapter) for the period of 2018-2020.
- Dr. G. Kar, Principal Scientist has been invited to deliver talk on the occasion of Engineer's Day celebration at Gandhi Institute of Excellent Technocrats, Bhubaneswar on September 15, 2017.
- Dr. S. Raychaudhuri, Principal Scientist has been invited to deliver talk in National Conference on Organic Waste Management for Environmental and Food Security jointly organized by ICAR-IISS & Indian Society of Soil Science (Bhopal chapter) during February 8-10, 2018.
- Dr. S. Raychaudhuri, Principal Scientist delivered keynote address in the World Water Summit 2018 held on March 22, 2018 at New Delhi.
- Dr. S.K. Rautaray, Principal Scientist acted as panelist in the session 'Management Structures for River Basins' organized by the Odisha Environment Congress held on December 21, 2017 at Regional Museum of Natural History, Bhubaneswar.
- Dr. M. Raychaudhuri, Principal Scientist acted as panelist in the Brain Storming Session 1-Water Use Efficiency Challenges and Way forward during 5thIndia Water Week 2017 held on October 12, 2017 at VigyanBhawan, New Delhi organized by Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India.
- Dr. M. Raychaudhuri, Principal Scientist acted as expert in the Seminar-4 'Safe Drinking Water for All' in the 5thIndia Water Week 2017 held on October 13, 2017 at VigyanBhawan New Delhi organized by Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India.
- Dr. M. Raychaudhuri, Principal Scientist acted as co-chairperson in National Conference on Organic Waste Management for Environmental and Food Security on February 9, 2018 jointly organized by ICAR-IISS& Indian Society of Soil Science (Bhopal chapter).
- Dr. S.K. Ambast, Director, visited Thimpu, Bhutan to attend SAARC Expert Consultation Meeting on 'Water Energy and Food Security Nexus' during July 3-6, 2017.
- Dr. A.K. Thakur, Principal Scientist, visited USA to attend and present paper in International Annual Meeting of ASA-CSSA-SSSA-2017 on 'Managing Global Resources for a Secure Future' during October 22-25, 2017 at Tampa, Florida, USA. His oral presentation was on paper entitled 'Impacts of cultivation practices and water management in the post-vegetative stage on rice grain yield and water productivity'.
- Dr. M. Raychaudhuri, Principal Scientist became women chess champion during 'ICAR Eastern Zone Sports Meet 2017' at ICAR-RCER, Patna held during November 13-16, 2017.

ICAR-IIWM sports team at ICAR-RCER, Patna

Research Management Meetings

Quinquennial Review Team (QRT) Meeting

The 5th Quinquennial Review Team of ICAR-IIWM and AICRP-IWM held its first meeting at ICAR-IIWM, Bhubaneswar during September 18-19, 2017 and second during November 10-12, 2017 at SKUAST, Jammu. The Team constituted the following members:

1	Dr. S. S. Magar, former Vice-Chancellor, BSKKV, Dapoli, Maharastra	Chairman
2	Dr. C.L. Acharya, former Director, ICAR- IISS, Bhopal	Member
3	Dr. M.G. Chandrakanth, Director, ISEC, Bengaluru	Member
4	Dr. R.K. Batta, Former PC, AICRP on WM	Member
5	Dr. J. M.L. Gulati, Former Dean, OUAT, Bhubaneswar	Member
6	Dr. S.D. Gorantiwar, Head, IDE, MPKV, Rahuri	Member
7	Dr. P. Nanda, Principal Scientist, ICAR-IIWM, Bhubaneswar	Member Secretary

QRT reviewed the achievements of ICAR-IIWM and AICRP-IWM for the period 2012-2017 as well as research proposals for next five years under different programs and themes of ICAR-IIWM and AICRP-IWM. Program leaders of ICAR-IIWM and Chief-Scientists of the respective centers presented the achievements made during 2012-2017 during the meetings.

QRT Meeting at ICAR-IIWM

Research Advisory Committee (RAC) Meetings

Members of Seventh RAC of ICAR-IIWM, Bhubaneswar

1	Dr. T.K. Sarkar, Former Project Director, WTC, ICAR-IARI, New Delhi	Chairman
2	Dr. A.K. Misra, Former Head, Division of Soil Physics, ICAR-IISS, Bhopal	Member
3	Dr. P.K. Mahapatra, Former Dean, College of Agriculture, OUAT, Bhubaneswar	Member
4	Dr. M.K. Jha, Professor, IIT, Kharagpur	Member
5	Dr. V.U.M. Rao, Former Project Coordinator, AICRP on Agro-meteorology	Member
6	Dr. S.K. Chaudhari, Asst. Director General (S&WM), ICAR, New Delhi	Member
7	Dr. S.K. Ambast, Director, ICAR-IIWM, Bhubaneswar	Member
8.	Dr. S. Roy Chowdhury, Principal Scientist, ICAR-IIWM, Bhubaneswar	Member Secretary

The third meeting of 7th Research Advisory Committee (RAC) of ICAR-Indian Institute of Water Management, Bhubaneswar was held duringFebruary 23-24, 2018 under the chairmanship of Dr. T. K. Sarkar. Dr. S.K. Ambast, Director, ICAR-IIWM welcomed esteemed Chairman and all members of RAC and presented research accomplishments of the Institute.Action taken report (ATR) was presented by Dr. S. Roy Chowdhury, Principal Scientist and Member-Secretary, RAC.Theme-wise presentations were also made by theme leaders of different programs.

Recommendations:

- Specific action plans on drip fertigation and other water management interventions to be prepared.

- Development of innovative and farmer's friendly-economically viable technology, their up-scaling and demonstration across different agro-ecosystems aligning with state department. Also, its methodologies be duly addressed in water policy and governance.
- Specific drainage guidelines for waterlogged areas in eastern India to be developed.
- Block-level drought and flood management interventions to be prepared.
- Training programs have to be more skill oriented with practical sessions.
- Water conservation, efficient and diversified use and environmental impact warrant attention under PMKSY.
- Enhancement of water-use efficiency under climate change scenarios and accordingly plan for research interventions for developing appropriate strategies for natural disastermitigation.
- Development of mobile application of web based expert system on agricultural water management in a farmer friendly manner.
- Sector-wise wastewater reclamation and recycling should be carried out for its productive use.

Institute Research Council (IRC) Meeting

Institute's Research Council (IRC) meeting was organized during May 18-20, 2017 with the Chairmanship of Dr. S.K. Ambast, Director, ICAR-IIWM. The results of the twenty four completed/ on-going in-house research projects under different programs were presented and deliberated in the meeting. Also, eight new research project proposals were presented and discussed.

2nd IRC meeting was held on July 7, 2017, and results of externally-funded projects- TSP, NICRA, LBS, GYG, MoA, PRP and Agri-CRP on Water as well as AICRP on Irrigation Water Management were discussed apart from two new research proposals. Based on the recommendations of the IRC meeting, new projects were decided to be further discussed in the monthly meeting held on July 28, 2017 and August 18, 2017. Dr. S.K. Ambast, Director & Chairman, IRC concluded with remarks and encouraged scientists to continue good work, timely reporting and systematic record keeping. He also emphasized for publication after completion of each project. Dr. S.K. Jena, Principal Scientist and Member Secretary, IRC organized the meeting.

Review Meeting of 'Agri-Consortia Research Platform on Water' Project of ICAR

Dr. K. Alagusundaram, DDG (NRM), ICAR in presence of Dr. S. K. Chaudhari, ADG (S&WM), NRM and Dr. S. K. Ambast, Director, ICAR-Indian Institute of Water Management, Bhubaneswar reviewed the progress and achievements of eight major themes under "Agri-Consortia Research Platform on Water" project during 2017–2018 at NRM Division, ICAR, New Delhi on March 23, 2018. The PIs and CCPIs of all the research projects from twenty six different Institutes/ Universities presented their technical and financial progress of the projects during the FY 2017-2018 in this meeting. DDG (NRM) expressed satisfaction on performance in the projects and emphasized the improvement in way of presentation of the results under the projects. Dr. Chaudhari and Dr. Ambast appreciated the work done and data recorded, and stressed on bringing some publications on the works done in different Institutes and Universities under the projects. Dr. P. Panigrahi, Senior Scientist of IIWM coordinated the review meeting.

HRD, Training and Capacity Building

Participation in trainings (Category-wise)

Official	Subject	Organization	Period
Dr. A.K. Nayak, Principal Scientist Mr. N. Manikandan, Scientist	Internal Auditor Training Course for ISO 9001:2015	TUV India Pvt. Ltd, Kolkata	August 17-18, 2017
Dr. O.P. Verma, Scientist Mr. N. Manikandan, Scientist Mr. Abhijit Sarkar, Scientist Mr. Partha Deb Roy, Scientist	Advanced capacity building program on 'Hydrological Study and Monitoring of Watersheds'	ICAR-IIWM, Bhubaneswar	September 11-15, 2017
Mr. S.K. Singh, AO Mr. J. Nayak, Assistant Mr. R.K. Dalai, Assistant Mr. N. K. Mallick, UDC	Public Finance Management System (PFMS) & GST	ICAR-NRRI, Cuttack	September 11-12, 2017
Dr. S. Pradhan, Scientist Dr. Rachana Dubey, Scientist Dr. Debabrata Sethi, Scientist	Advanced capacity building program on 'Hydrological Study and Monitoring of Watersheds'	ICAR-IIWM, Bhubaneswar	September 18-22, 2017
Dr. O.P. Verma, Scientist Mr. Abhijit Sarkar, Scientist	Advanced capacity building program on 'Concepts of Standard Design, Layout of Different Structural Measures in Watersheds'	ICAR-IIWM, Bhubaneswar	October 9-13, 2017
Dr. S. Pradhan, Scientist Dr. Rachana Dubey, Scientist	Advanced capacity building program on 'Concepts of Standard Design, Layout of Different Structural Measures in Watersheds'	ICAR-IIWM, Bhubaneswar	October 24-28, 2017
Mr. B.K. Acharya, Technical Officer	Capacity Building & Skill Upgradation Program on Farm Management	ICAR-IIFSR, Modipuram	October 24-28, 2017
Dr. Debabrata Sethi, Scientist Mr. Partha Deb Roy, Scientist	Advanced capacity building program on 'Concepts of Standard Design, Layout of Different Structural Measures in Watersheds'	ICAR-IIWM, Bhubaneswar	November 6-10, 2017
Mr. N. Manikandan, Scientist	Advanced capacity building program on 'Concepts of Standard Design, Layout of Different Structural Measures in Watersheds'	ICAR-IIWM, Bhubaneswar	November 21-25, 2017
Mr. V.K. Sahoo, F&AO Mr. A. Mallick, AAO	Public Finance Management System (PFMS) & GST	ICAR-NRRI, Cuttack	November 27-28, 2017
Mr. A.K. Binakar, Senior Technical Assistant (Driver)	Competency Enhancement Program on Automobile Maintenance, Road Safety And Behavioral Skill Development	ICAR-CIAE, Bhopal	November 27-28, 2017
Dr. S.K. Jena, Principal Scientist	Management Development Programme on Leadership Development	ICAR-NAARM, Hyderabad	December 12- 23, 2017
Dr. K.G. Mandal, Principal Scientist Dr. D.K. Panda, Principal Scientist	Multivariate Data Analysis	ICAR-NAARM, Hyderabad	December 14-20, 2017
Dr. S. Pradhan, Scientist Dr. Debabrata Sethi, Scientist	Advanced capacity building program on 'Improving Water Productivity in Rainfed Agriculture'	ICAR-IIWM, Bhubaneswar	December 18-22, 2017
Mrs. Sunanda Naik, ACTO (Library)	Training-cum Awareness Workshop on J-Gate@CeRA for North-East Region	ICAR-CIFA, Bhubaneswar	December 19, 2017
Mr. P. Deb Roy, Scientist	'Statistical Advances for Agricultural Data Analysis'	ICAR-IASRI, New Delhi	March 3-23, 2018

Training organized

Subject	Place	Period	Participants
Summer training program for M. Tech. students of CAET, OUAT, Bhubaneswar on various aspects of water management	ICAR-IIWM, Bhubaneswar	May 16-June 15, 2017	3
Summer training program for students of SWE, Faculty of Agricultural Engineering, Dr. R.P.C.A.U., Pusa, Bihar on various aspects of water management	ICAR-IIWM, Bhubaneswar	June 12-July 2, 2017	2
Professional Attachment Training to an ARS Scientist	ICAR-IIWM, Bhubaneswar	December 15- March 14, 2018	01
Model Training Course (MTC) on 'Improving land and water productivity through soil and water management'	ICAR-IIWM, Bhubaneswar	January 31-February 7, 2018	22

Farmers' training programsorganized

Subject	Place	Period	Participants
Farmer's training program under Farmer's FIRSTproject	Khuntapingu, Malarpada and Jamuda villages, Keonjhar	September 12-14, 2017	370
KisanGosthi	ICAR-IIWM Research Farm	November 10, 2017	60
Farmer's training program under Farmer's FIRST project	KVK, Keonjhar	December 27-29, 2017	28
Training and exposure visit program under TSP project	Mahuljore village, Sundargarh	November 29-30, 2017	100
'*Krishak Pathsala*' at Odisha state level exhibition	Barmunda, Bhubaneswar	March 9, 2018	
Krishi Jal Prabandhan Mela (under *Krishi Unnati Mela*-2018)		March 17, 2018	1019
Farmers' training program on 'Acquaintance on adoption of the pressurized irrigation system for increased crop productivity'	Nagpur minor, Balianta, Khurda	March 20, 2018	53

Farmers / Students-Experts Interaction-cum-Practical Training Programs

Farmers/ Students from	Date	Participants
Bolangir, Odisha (ATMA)	April 11, 2017	10
Ramnagar, Medinipur, West Bengal	May 31, 2017	20
Purba Medinipur, West Bengal	June 7, 2017	40
Egra block II, Purba Medinipur, West Bengal	July 26, 2017	23
OUAT, Bhubaneswar	October 26, 2017	41
SOA University, Bhubaneswar	November 28, 2017	30
Katni Block, Bilaspur, M.P.	December 8, 2017	25
Katni Block, Bilaspur, M.P.	February 8, 2018	68

Advanced Capacity Building Program under PMKSY

Ten advanced capacity building program under Pradhan MantriKrishiSinchayeeYojana (PMKSY) was conducted at ICAR-Indian Institute of Water Management, Bhubaneswar for Assistant Soil Conservation Officer/ Assistant Project Directors of the Directorate of Soil Conservation and Watershed Development, Govt. of Odisha. Dr. S.K. Ambast, Director, ICAR-IIWM, Bhubaneswar was of these training programs.

Detail of programs	Course-Director /Coordinators	Duration	No. of participants
Hydrological Study and Monitoring of Watersheds	Dr. S.K. Ambast/ Dr. A. Mishra & Dr. S.K. Jena	August 8-12, 2017	20
		August 28-Septemeber 1, 2017	20
		September 11-15, 2017	20
		September 18-22, 2017	20
Concepts of Standard Design, Layout of Different Structural Measures in Watersheds	Dr. S.K. Ambast/ Dr. R.K. Panda & Dr. R.R. Sethi	October 9-13, 2017	25
		October 24-28, 2017	23
		November 6-10, 2017	20
		November 21-25, 2017	28
Improving Water Productivity in Rain-fed Agriculture	Dr. S.K. Ambast/ Dr. S. Mohanty & Dr. P. Panigrahi	December 18-22, 2017	21
		January 15-19, 2018	27

Inter-State Farmers Training Program under PMKSY

Three Inter–State Farmers Training Program under *Pradhan Mantri Krishi Sinchayee Yojana* (PMKSY) was conducted at ICAR-Indian Institute of Water Management, Bhubaneswar for farmers, sponsored by state unit of ATMA.

Detail of programs	Convener / Coordinators	Duration	No. of participants
Doguni aay evum surakshita ajeevika keliye jal sanrkshan evum dak shsinchai pranali	Dr. S.K. Ambast / Dr. M.K. Sinha & Dr. R. Dubey	November 27-30, 2017	11
Doguniki sani aay keliye sinchai jal prabandhan	Dr. S.K. Ambast/ Dr. M.K. Sinha, Dr. S. Pradhan & Dr. D. Sethi	January 9-11, 2018	26
Phasal utpadan evm khadya suraksha keliye krishi jal prabandhan	Dr. S.K. Ambast/ Dr. M.K. Sinha, Mr. N. Manikandan & Mr. P. Deb Roy	February 12-16, 2018	22

HRD fund allocation and utilization during 2017-2018

Budget Head	Budget (Lakhs)	Expenditure (Lakhs)
H.R.D.	4.00	2.25

Exhibitions

Institute's achievements were displayed/ showcased in the following exhibitions held in different locations:

Events	Place	Date / Period
Inauguration of Highly Sensitive Laboratory at International Centre for Foot & Mouth Disease (ICFMD)	ICFMD, Jatni, Khorda	April 1, 2017
Kisan Kalyan Mela	Mahatma Gandhi Central University, Motihari, Bihar	April 15-19, 2017
Foundation Day Celebration of ICAR - NRRI, Cuttack	ICAR-NRRI, Cuttack	April 23, 2017
Celebration of *Mahila Kishan Diwas* on World Food Day	ICAR-CIWA, Bhubaneswar	October 16, 2017
82nd Annual Convention of Indian Society of Soil Science	Amity University, Kolkata	December 11-14, 2017
Exhibition by OSEE	ICAR-CIWA, Bhubaneswar	February 1-3, 2018
State-level Exhibition	Barmunda, Bhubaneswar	March 6-9, 2018
Krishi Jal Prabandhan Mela - 2018	ICAR-IIWM, Bhubaneswar	March 17, 2018

Women Empowerment

Farmer's Training under TSP

A field demonstration-cum-training program on 'Pump operation, maintenance and irrigation application techniques' was conducted at Birjaberna village in Sadar block, Sundargarh under TSP project during November 29-30, 2017. The program was attended by 100 farmers including 20 women participants. Different irrigation water application techniques, field demonstration on water application methods in different crops, crop water requirement and aquaculture practices to enhance the farm income were also briefed to the famers during the training program. Dr. R.K. Panda, Principal Scientist coordinated the program.

Farmer's Training under Farmer's FIRST Project

- Three one-day farmer-training programs were organized under Farmer's FIRST Project at Khuntapingu, Malarpada and Jamuda villages (Dist. Keonjhar) on September 12, 13 and 14, 2017, respectively. A total of 370 farmers including women farmers participated in the training programs. Scientists from ICAR-IIWM, district-level as well as block-level personnel of watershed, agriculture, veterinary, horticulture and fishery departments provided training to the farmers. A WhatsApp group was formed during the training in order to use social media as a tool for sharing images and videos of problems faced in farming and get appropriate solutions from the expert scientists.
- Another three-day farmers' training was organized on 'Entrepreneurship development for income generation and enhancement of water productivity' at KVK, Keonjhar under Farmer's FIRST Project during December 27-29, 2017. A total of 28 farmers and farm women from three villages (Khuntapingu, Malarpada and Jamuda) of Saharpada block (Dist. Keonjhar) participated in the training programme. Participants had also practical demonstrations on drip irrigation, portable sprinkler irrigation and mushroom farming. Dr. P. Nanda, Principal Scientist and Dr. D. Sethi, Scientist coordinated the program.

Participations

Conferences, Meetings, Workshops, Symposia, Deputations

Official	Name of the Seminar / workshop / training / conference	Organized by	Period
Dr. S.K. Ambast Dr. P.S. Brahmanand	Pre-project Meeting on IBFI	IWMI, New Delhi	April 10-11, 2017
Dr. S.K. Ambast	Interaction Workshop on 'Optimal Use of Groundwater in Agriculture'	Central Groundwater Authority, New Delhi	April 12, 2017
Dr. S.K. Ambast Dr. P.S. Brahmanand	National Seminar on 'Agronomic Approaches for Climate Resilience in Agriculture'	RARS, ANGRAU, Kurnool, AP	May 2, 2017
Dr. S.K. Ambast Dr. H.K. Dash	Doubling Farmers' Income in Odisha	ICAR-NRRI, Cuttack	May 8, 2017
All Scientists of ICAR-IIWM	Brain-storming Session on Translating Research into Technology	ICAR-IIWM, Bhubaneswar	May12, 2017
Dr. H.K. Dash	Meeting to Finalize the Methodology for Impact Study	ICAR-CIWA, Bhubaneswar and OWDM, Odisha	May 16, 2017
Dr. S.K. Ambast	Indo-Israel Cooperation on Water Management	PMO, New Delhi	May 29, 2017
Dr. S.K. Ambast Dr. S. Raychaudhuri	Expert Committee Meeting of NASF on 'Conservation Agriculture and Climate Change, Micronutrients and their Use Efficiency, Precision and Controlled Environment Agriculture, Water Quality and Productivity'	National Agricultural Science Fund, ICAR, New Delhi	May 30, 2017
Dr. S.K. Rautaray Dr. K.G. Mandal Dr. P. K.Panda Dr. R. Dubey	International Conference Organic Farming for Sustainable Agriculture	OUAT, Bhubaneswar& Centre for Environment and Economic Development (CEED), New Delhi	June2-3, 2017
Dr. P.S. Brahmanand	Policy Dialogue Workshop on 'Flood Index Insurance and Drought Management for Agricultural Development'	ICAR-RCER, Patna, Bihar	June 7, 2017
Dr. S. Roy Chowdhury Dr. R.K. Panda	Workshop on 'Tracking Management Initiatives for Water Security'	NITI Aayog, New Delhi	June14, 2017
Dr. S.K. Ambast	SAARC Regional Consultation Meet at Thimpu, Bhutan	SAARC Agriculture Centre, Bangladesh	July 3-5, 2017
Dr. S.K. Ambast	SAU's VC and ICAR Directors Conference	ICAR, New Delhi	July 16, 2017
Dr. S.K. Ambast Dr. S. Roy Chowdhury	State-level Executive Committee Meeting on PKVY	Dept. of Agriculture and Farmers' Empowerment, GoO	July 19, 2017
Dr. S.K. Jena	Launch Workshop of the DST Funded Project on 'Revival of Village Ponds through Scientific Interventions'	PAU, Ludhiana	July 21-22, 2017
Dr. S.K. Ambast Dr. S. Roy Chowdhury Dr. K.G. Mandal Dr. A.K. Thakur	National Consultation on 'Bio-resources for Sustainable Development- Biodiversity, Agriculture and Health'	Institute of Life Sciences (ILS), Bhubaneswar &Institute of Bio-resources and Sustainable Development (IBSD), Imphal	July 31-August 2, 2017
Dr. P.S. Brahmanand	Divisional Review Meeting of Foreign-aided Projects	NRM division, ICAR, New Delhi	August 1, 2017
Dr. S.K. Ambast	Inception Workshop of ICAR-IWMI Collaborative Project	MPKV, Rahuri	August 22-24, 2017
Dr. S.K. Ambast Dr. R.K. Panda	Workshop on 'Reshaping Agricultural Research Education and Extension Systems Management for 2030'	ICAR-NAARM, Hyderabad	August 31, 2017
Dr. S.K. Rautaray	Field Day on Dragon Fruit	Central Horticultural Experiment Station, Bhubaneswar	September 1, 2017
Dr. S.K. Rautaray	World Coconut Day	Coconut Development Board, Bhubaneswar	September 2, 2017
Dr. M. Das	Meeting for Agenda of Coordination of Chronic Kidney Disease Research / Surveillance	RMRC, Bhubaneswar	September 14, 2017
Mr. N. Manikandan	Workshop on Delivery of Agro-meteorological Advisory Services at Block/ Village Level through SMS	IMD, New Delhi, DAFE, GoO & OUAT, Bhubaneswar	October 10, 2017

Dr. M. Raychaudhuri	5th India Water Week	Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India, New Delhi	October 11-14, 2017
Dr. A.K. Thakur	International Annual Meeting of ASA-CSSA-SSSA on 'Managing Global Resources for a Secure Future'	ASA-CSSA-SSSA, USA	October 22-25, 2017
Dr. P.S. Brahmanand	National level Consultation Workshop on 'Finalization of Template for State Specific Action Plan on Water'	National Water Mission, Ministry of Water Resources, Government of India	October 23, 2017
Dr. M. Raychaudhuri Dr. S. Raychaudhuri Mr. P. Deb Roy	37th Annual Convention of Indian Society of Soil Science, Bhubaneswar Chapter	Bhubaneswar Chapter, ISSS, OUAT, Bhubaneswar	October 31, 2017
Dr. S. Raychaudhuri	Information & Networking Event: EU-India Call on Water	Research and Innovation Section of the Delegation of the European Union to India, (EU), Department of Science & Technology (DST) and Department of Biotechnology, GOI, New Delhi	November 3, 2017
Dr. P.S. Brahmanand	ICAR Winter School 'Developments in Organic Farming in Tropical Islands in India'	ICAR-CIARI, Port Blair	November 18, 2017
All Scientists of ICAR-IIWM	Brainstorming Workshop 'Converting Extreme Rainfall Events into Opportunities'	ICAR-Indian Institute of Water Management, Bhubaneswar	November 22, 2017
Dr. S. Roy Chowdhury Dr. R. Dubey	National Conference of 'Plant Physiology Emerging Role of Plant Physiology for Food Security and Climate Resilient Agriculture'	ISPP, New Delhi and IGKV, Raipur	November 23-25, 2017
Dr. S.K. Ambast	National Symposium on 'Indian Standards for Irrigation Equipment's and Drainage Systems'	BIS, New Delhi & Jain Irrigations, Jalgaon	December 5-6, 2017
Dr. S.K. Ambast	Interactive Seminar on 'The Foresight Agrimonde-Terra for 2050: Indian Perspective'	NRM, ICAR, New Delhi	December 7-9, 2017
Dr. S.K. Ambast Dr. M. Das Dr. G. Kar	82nd Annual Convention of Indian Society of Soil Science, New Delhi	Indian Society of Soil Science, Kolkata Chapter, Kolkata	December 11-14, 2017
Dr. P.S. Brahmanand	Stakeholder Meeting of NAIP Sponsored sub-project –'Design and Development of Rubber Dams for Watersheds'	ICAR-CIRCOT, Mumbai	December 14, 2017
Dr. S.K. Ambast Dr. S.K. Rautaray	Meeting on 'Environment and Sustainable River Basin Management'	Regional Museum of Natural History, Bhubaneswar	December 20-22, 2017
Dr. M. Das	XXV National Children Science Congress	DST, Govt. of India, Ahmedabad, Gujarat	December 27-31, 2017
Dr. P. K.Panda	Environmental Pollution : A Threat to Mankind	G. W. College, Jagatsinghpur	January 10-11, 2018
Dr. S.K. Ambast Dr. P. Panigrahi	International Conference on 'Water and Wastewater Management and Modelling'	Central University, Ranchi	January 16-17, 2018
Dr. S.K. Jena	National Remote Sensing Centre (NRSC) User Meet-2018 on 'Space4All: For Inclusive and Sustainable Growth'& Geospatial World Forum 2018 International Conference	NRSC, Hyderabad	January 17-19, 2018
Dr. P. Panigrahi	National Seminar on 'Sustainable Rice Production Technology for Increasing the Farmers Income'	IGKV, Raipur	January 20-21, 2018
Dr. S.K. Jena	Review Workshop of the DST Funded Project on 'Revival of Village Ponds through Scientific Interventions'	WTC, ICAR-IARI, New Delhi	January 24, 2018

Dr. P.S. Brahmanand	Divisional Review Meeting of Foreign-aided Projects	NRM division, ICAR, New Delhi	January 31, 2018
Dr. S.K. Ambast Dr. H.K. Dash Dr. D. Sethi Mr. S.K. Dash	1st International Extension Congress on 'Extension Strategies and Challenges for Doubling Farmers' Income'	OSEE and ICAR-CIWA, Bhubaneswar	February 1-3, 2018
Dr. G. Kar	Annual Meeting of West Bengal Academy of Science and Technology	West Bengal Academy of Science and Technology at CSIR-IICB, Kolkata	February 5, 2018
Dr. S.K. Ambast Dr. S.K. Rautaray Dr. M.K. Sinha Dr. P.K. Panda Dr. S. Mohanty Dr. P. Panigrahi Dr. A.K. Nayak Dr. O.P. Verma Dr. D. Sethi Mr. N. Manikandan	3rd ARRW International Symposium on 'Frontiers of Rice Research for Improving Productivity, Profitability and Climate Resilience'	ARRW & ICAR-NRRI, Cuttack	February 6–9, 2018
Dr. M. Raychaudhuri Dr. S. Raychaudhuri	National Conference on 'Organic Waste Management for Environmental and Food Security'	ICAR-IISS& Bhopal Chapter of ISSS, Bhopal	February 8-10, 2018
Dr. R.K. Panda Dr. S.K. Jena	International conference on 'Sustainable Technologies for Intelligent Water Management'	IIT, Roorkee	February16-19, 2018
Dr. M. Das	Meeting on 'Skill Development Partnership with Agriculture Skill Council of India (ASCI)'	IMAGE, Bhubaneswar	February 19, 2018
Dr. H.K. Dash Dr. D. Sethi Mrs. S. Naik Mr. B. Dutta	State Level Agricultural Exhibition	Government of Odisha, Bhubaneswar	March 6-9, 2018
Dr. R.R. Sethi Dr. R. Dubey Mrs. S. Naik	Workshop on 'Prevention of Sexual Harassment at Workplace'	ICAR-CIWA, Bhubaneswar	March 8, 2018
All Scientists of ICAR-IIWM	*Krishi Jal Prabandhan Mela*-2018	ICAR-IIWM, Bhubaneswar	March 17, 2018
All Scientists of ICAR-IIWM	'World Water Day'	ICAR-IIWM, Bhubaneswar	March 22, 2018
Dr. S.K. Ambast Dr. P. Nanda Dr. S. Raychaudhuri Dr. S.K. Jena Dr. R.K. Mohanty Dr. P. Panigrahi	Review Meeting of 'CRP on Water'	ICAR-IIWM at ICAR-HQ, New Delhi	March 23, 2018
Dr. O.P. Verma	*Nagar Rajbhasha Karyanvyan Samiti, Bhubaneswar Ki 62vi Baitahk*	IIT, Bhubaneswar	March 28, 2018

Major Events
2017-18

Dr. S. Pasupalak, Hon'ble Vice-Chancellor, OUAT, Bhubaneswar & Dr. Dipankar Saha, Member, CGWB, MoWR, RD & GR, Govt. of India, New Delhi on the occasion of ICAR-IIWM's 30th Foundation Day Celebration on May 12, 2017

Independence Day Celebration at ICAR-IIWM

Visit of Hon'ble Union Minister of State for Agriculture & Farmers Welfare Shri Sudarshan Bhagat on May 23, 2017

ICAR- IIWM celebrated International Yoga Day on June 21, 2017

Hindi Pakhwada at ICAR-IIWM during September 14-28, 2017

Visit of Watershed Development Doyens at ICAR-IIWM- Rajendra Singh, Popatrao Baguji Pawar and Laxman Singh during Advanced Capacity Building Training Program under PMKSY

Secretary DARE and Director General, ICAR, Dr. T. Mohapatra visited ICAR-IIWM during Brainstorming Workshop on November 22, 2017

ICAR-IIWM celebrated 'Agricultural Education Day' on December 3, 2017

Human-chain formation during Vigilance Awareness Week (October 30-November 4, 2017)

Krishi Jal Prabandhan Mela at ICAR-IIWM on March 17, 2018

Visit of Chairman, ASRB, Dr. A.K. Srivastava at ICAR-IIWM on February 3, 2018

Hon'ble Prime Minister, Sh. Narendra Modi ji, addressing the farmers during Krishi Unnati Mela

Model Training Course on 'Improving land and water productivity through soil and water management' at ICAR-IIWM during Jan. 31-Feb. 7, 2018

Republic Day Celebration at ICAR-IIWM

Secretary DARE and Director General, ICAR, Dr. T. Mohapatra visited ICAR-IIWM during World Water Day on March 22, 2018

Mera Gaon Mera Gaurav

Six groups of scientists of ICAR-IIWM adopted thirty villages across seven blocks spreading over five districts of Odisha under the '*Mera Gaon Mera Gaurav*' program. Farmers' have been given mobile based services for pest and disease control in crops, literature supports for soil collection, water storage and use, *in-situ* rainwater conservation technique along with creating general awareness and imparted need based training on various aspects of farming. Linkages have been established with state government offices (seed production, organic farming, state agriculture and horticulture departments etc.), OUAT, Bhubaneswar, KVKs, ICAR-CIFA, Bhubaneswar and other allied organizations.

Information on villages adopted under MGMG Program

Group ID	Name of the villages	Name of Block and District	Number of farm families
Group A	Khalibandha, Nuagaon, Sadeiberini, Gajamara, Saptasajyapada	Block-DhenkanalSadar District-Dhenkanal	631
Group B	Bhakrasahi, Poijhari, Haladibasanta, Naranpur, Sarata	Block-Balipatna District-Khorda	439
Group C	Sukalaaisanyapara, Alisha, Churali, Parimanoipur, Sukalapara	Block-Satyabadi and Kanas District-Puri	674
Group D	Chhatabar, Durgapur, Giringaput, Haridamada, Jammujhari	Block- Bhubaneswar and Jatni District-Khorda	755
Group E	Khadal, Irikundal, Hasimnagar, Dhinkia, Bindhapada	Block-Tirtol District-Jagatsinghpur	271
Group F	Madana, Naindipur, Chandapalla, Patakura, Jagannathpur	Block-Garadpur District-Kendrapara	820

Information on general awareness created

Sl. No.	Subject matter
i)	Irrigation scheduling for field crops
ii)	Agro-techniques and value addition in tuber crops
iii)	Distribution ofpineapple suckers (var. Queen) and banana saplings (var. G-9) seedlings
iv)	Benefit of line transplanting and fertilizer application in rice
v)	SRI method of rice cultivation
vi)	Problems and remedies in pumpkin, pointed gourd and potato
vii)	Pest and disease control in rice and vegetable crops
viii)	Pond-based farming system
ix)	*Swaccha Bharat Abhiyan*, Soil health card, Awareness Gram Sabha
x)	Soil sample collection and water conservation techniques
xi)	Micro-irrigation
xii)	Rainwater conservation and rice-fish farming
xiii)	Integrated fish-water chestnut co-production system
xiv)	Integrated farming systems, pisciculture and poultry farming

Training and interaction meeting organized under adopted villages

Detail of programs	Place and date	No. of beneficiary farmers
Visit of farmers in *Kisan Goshti* at International Centre for Foot and Mouth Disease, Arugul, Bhubaneswar	Chatabar, Durgapur, Giringaput, Haridamada and Jammujhari villages April 1, 2017	60
Interaction meeting on problems in pointed gourd and potato	Bhakarsahi, Balipatna Block April 17, 2017	21
Farmer-Scientist interaction on problems in ridge gourd and cucumber	Chatabar village April 22, 2017	10
Scientist-farmer interaction meeting on crop establishment, fertilizer application and irrigation methods for summer crops, and importance of animal health management	Khalibandha, Nuagaon, villages, Dhenkanal April 22, 2017	149
Awareness program on ploughing	Churali, Satyabadi, Puri April 29, 2017	22
Distribution of pineapple suckers (var. Queen) and training on its package and practices	Khadala village, Jagatsinghpur May 5, 2017	11
Training program on agro-techniques and value addition in tuber crops	Jammujhari village May 6, 2017	32
Scientist-farmer interaction meeting on sowing and management of vegetable crops in up lands and rice cultivation in medium and low lands	Sadeiberini, Gajamara, villages, Dhenkanal June 24, 2017	42
Field demonstration on farm mechanization	Erikindala,Dhinkia villages,Tirtol block June 24, 2017	20
Interaction meeting on problems in pumpkin crop	Bhakarsahi, Balipatna Block June 28, 2017	19
Awareness program on cultivation of *kharif* season rice, poultry farming and pond-based farming system	Alisha, Satyabadi, Puri June 28, 2017	35
Distribution of banana saplings (var. G-9) and training on its package and practices	Chatabar village July, 15 2017	28
Farmer-Scientist interaction on pond-based integrated farming system in waterlogged areas	Sukalpada, Puri July 29, 2017	78
Scientist-Farmers interaction meeting line transplanting and basal fertilizers application for paddy	Sarat and Bhakarsahi villages, Balipatna Block July 29, 2017	16
Scientist-farmer interaction meeting on crop, nutrients and water management in rice and pulse crops; animal health management	Nuagaon and Gajamara villages, Dhenkanal July 29, 2017	68
Interaction meeting on water management practices and management measures for control of pests and diseases in rice and vegetable crops	Madana Village, Garadpur Block, Kendrapara August 26, 2017	12
Farmer-Scientist interaction on aquaculture	Sukal, Puri August 26, 2017	32
Farmer-Scientist interaction meet on pest and diseases problem in paddy	Haridamada village August 26, 2017	5
Farmer-Scientist interaction meeting on line sowing in rice	Dhinkia village, Tirtol block September 1, 2017	10

Scientist-farmer interaction meeting on water conservation, insect and pest management, fertilizer scheduling in rice and pulse crops	Saptasajya para and Sadeiberini villages, Dhenkanal September 23, 2017	53
Farmers training on eco-friendly agricultural practices	Sarat village, Balipatna Block October 7, 2017	34
Interaction meeting on control of pests and diseases of *rabi* crops and organized '*Awareness Gram Sabha*'	Madana Village, Garadpur Block, Kendrapara November 2, 2017	24
'*Rabi Kisan Gosthi*' on demonstration of runoff recycling model for production and profit enhancement and drip fertigation in banana	Chhatabar, Durgapur, Giringaput, Haridamala and Jammujhari villages November 10, 2017	60
Farmers training on cultivation practices for groundnut	Bhakarsahi, Balipatna Block November 18, 2017	40
Farmer-Scientist interaction meeting for enhancing productivity and income through integrating agriculture and aquaculture	Hasim Nagar village, Tirtol block, November 18, 2017	15
Scientist-farmer interaction meeting on crop and water management in *kharif* rice; conservation of rainwater in fields and its effective use	Gajamara and Nuagaon villages, Dhenkanal November 25, 2017	68
Farmers training on *rabi* rice cultivation	Alisha village, Puri November 29, 2017	15
Scientist-farmer interaction meeting on mechanical harvesting of rice, growing pulses, groundnut, mustard etc. along with water, insect and pest management for *rabi* crops	Gajamara and Khalibandha villages, Dhenkanal December 20, 2017	57
Farmer-Scientist interaction on vegetables crops for *rabi* season	Jammujhari village December 23, 2017	25
Farmer-Scientist interaction on integrated farming system and water management in *rabi* and summer crops	Bindhapada village, Tirtol block January 20, 2018	10
Awareness meeting on insects pest and diseases in groundnut crop	Bhakarsahi village January 27, 2018	26
Farmer's-Scientist's interaction on salinity of groundwater in waterlogged areas	Sukal village, Puri February 4, 2018	21
Farmers' interaction meet on integrated farming system, soil management, fish culture, water management in *rabi* and summer crops	Hasimnagar village March 3, 2018	15
Farmer-Scientist interaction on water management in summer crops	Durgapur, Giringaput, Haridamada villages March 5, 2018	05
Interaction meeting on improving the productivity of *rabi* mungbean	Sarat village March 14, 2018	31

SWACHA BHARAT ABHIYAN

Swachha Bharat Abhiyan

The Director and staff of ICAR-IIWM, Bhubaneswar participated actively in *Swachh Bharat Abhiyan* and 33 number of cleanliness campaigns were conducted during 2017-2018 in the Institute main campus, public places and tourist spots. The *Swachhata Pakhwara* was celebrated during May 16-31, 2017 as per the directives of ICAR and Government of India. Physical cleaning of drainage lines, wastewater treatment using filters ensured better sanitation and solid waste management in the institute campus. Shri Sudarshan Bhagat, Hon'ble Union Minister of State, Agriculture & Farmers' Welfare, GoI visited the wastewater treatment site of the Institute during his visit. Other activities viz. clearance of E-waste, pruning of shrubs, beautification of the Institute and plantation of tree saplings were also performed during the period.

All the staff members actively participated in cleanliness campaign on the occasion of celebration of '*Sewa Diwas*' during September 15- October 2, 2017. *Swachhata Shapath* was administered by the Director of the institute to all the staff members twice on September 15 and October 2, 2017. During cleanliness drive, weeds and polythene articles were removed from the institute campus; participated in scrapping and removing of silt/soil deposited on both the corners of Daya River Bridge, 20-km away from the Institute. The staff members also participated in removal of night soil and slit deposited in the drainage line causing severe obstruction to the sewage/toilet water flow on the occasion of celebration of '*Samagra Swachhta Diwas*' on September 24, 2017. An awareness campaign was organized for public about the need for creating proper toilet facility in the disadvantageous areas. They also participated in removing weeds and non-biodegradable articles like, plastic and polythene adjacent to the main road passing through the *Santal Sahi Basti*. Major emphasis was given on eradication of most obnoxious weed *Parthenium* sp. on the occasion of celebration of '*Sarvatra Swachhta Diwas*' on September 25, 2017. On October 1, 2017, ICAR-IIWM staff cleaned the premises in front of Nandankanan Zoo. Six persons were awarded with *Swachhta Puraskar*-2017 for their excellent efforts in ensuring their surroundings clean and for their overall initiative and leadership in *Swachh Bharat Abhiyan* on the occasion of Gandhi Jayanti on October 2, 2017. Dr. P.S. Brahmanand, Principal Scientist & Nodal Officer, *Swachh Bharat Abhiyan* coordinated these activities.

A brief account on Swachha Bharat Abhiyan at ICAR-IIWM (April 1, 2017-March, 31 2018)

S. No.	Nature of Activities	Number of Events	Number of Hours
1	Digitization of Office Records/ e-office	02	05
2	Basic Maintenance	24	48
3	Sanitation and SWM	03	06
4	Cleaning and Beautification of Surrounding Areas	09	18
5	Vermi-composting/Composting of Bio-degradable Waste Management & Other Activities on Generate of Wealth for Waste	02	02
6	Used Water for Agriculture/ Horticulture Application	02	04
7	*Swachhta* Awareness at Local Level	09	18
8	*Swachhta* Workshops	01	02
9	*Swachhta* Pledge	04	01
10	Display and Banner	05	-
11	Foster Healthy Competition	02	02
12	Involvement of Print and Electronic Media	03	-
13	Involving and with the Help of the Farmers, Farmwomen and Village Youth in Their Adopted Villages (No. of Adopted Villages)	05	10
	Total Number of Staff Involved in the Activities	1096 (Combined Number on All Basic Cleanliness Activities with an Average of 45.6 Persons per Activity)	

Personnel

As on 31-03-2018

Dr. Sunil Kumar Ambast, Director

SCIENTIFIC		
Sl. No.	Name	Designation
1	Dr. R.C. Srivastava#	Principal Scientist
2	Dr. Atmaram Mishra	Principal Scientist
3	Dr. M. Das	Principal Scientist
4	Dr. S. Roy Chowdhury	Principal Scientist
5	Dr. P. Nanda	Principal Scientist
6	Dr. R.K. Panda	Principal Scientist
7	Dr. S.K. Rautaray	Principal Scientist
8	Dr. G. Kar	Principal Scientist
9	Dr. S.K. Jena	Principal Scientist
10	Dr. M. Raychaudhuri	Principal Scientist
11	Dr. S. Raychaudhuri	Principal Scientist
12	Dr. R.K. Mohanty	Principal Scientist
13	Dr. M. K. Sinha	Principal Scientist
14	Dr. K.G. Mandal	Principal Scientist
15	Dr. H.K. Dash	Principal Scientist
16	Dr. P.K. Panda	Principal Scientist
17	Dr. A.K. Thakur	Principal Scientist
18	Dr. P.S. Brahmanand	Principal Scientist
19	Dr. S. Mohanty	Principal Scientist
20	Dr. D.K. Panda	Principal Scientist
21	Dr. Ranu Rani Sethi	Principal Scientist
22	Dr. A.K. Nayak	Principal Scientist
23	Dr. P. Panigrahi	Senior Scientist
24	Dr. O.P. Verma	Scientist
25	Dr. Sanatan Pradhan	Scientist
26	Dr. Debabrata Sethi	Scientist
27	Dr. Rachana Dubey	Scientist
28	Mrs. Prativa Sahu*	Scientist
29	Mr. N. Manikandan	Scientist
30	Mr. Abhijit Sarkar	Scientist
31	Mr. Partha Deb Roy	Scientist

TECHNICAL		
Sl. No.	Name	Designation
1	Mrs. Sunanda Naik	Asst. Chief Technical Officer
2	Mr. Chhote Lal	Senior Technical Officer
3	Mr. R.C. Jena	Technical Officer
4	Mr. P.C. Singh Tiyu	Technical Officer
5	Mr. S.K. Dash	Technical Officer
6	Mr. B.K. Acharya	Technical Officer
7	Mr. S. Lenka	Technical Officer
8	Mr. P. Barda	Senior Technical Assistant
9	Mr. A.K. Binakar	Senior Technical Assistant (Driver)
10	Mr. L. Singh Tiyu	Senior Technical Assistant (Driver)
11	Mr. A. Parida	Senior Technician

ADMINISTRATION		
Sl. No.	Name	Designation
1	Mr. S.K. Singh	Administrative Officer
2	Mr. Vinod K. Sahoo	Finance & Accounts Officer
3	Mr. A. Mallik	Asst. Administrative Officer
4	Mrs. M. Padhi	Private Secretary
5	Mr. Trilochan Raut	Personal Assistant
6	Mr. J. Nayak	Assistant
7	Mr. R.K. Dalai	Assistant
8	Mr. A.K. Pradhan	Upper Division Clerk
9	Mr. N.K. Mallick	Upper Division Clerk
10	Mr. C.R. Khuntia	Lower Division Clerk
11	Mr. B.S. Upadhyaya	Lower Division Clerk
12	Mr. S.C. Das	Lower Division Clerk

SUPPORTING		
Sl. No.	Name	Designation
1	Mr. Sanatan Das	Skilled Support Staff
2	Mr. B.N. Naik	Skilled Support Staff
3	Mr. S.K. Panda	Skilled Support Staff
4	Mr. B. Dutta	Skilled Support Staff

#-on deputation
*-on study leave (since August, 2017)

Joining & Promotion

JOINING & PROMOTION

- Dr. Hemant Kumar Das, Principal Scientist (Agricultural Economics), joined ICAR-IIWM on April, 01, 2017 after transfer from ICAR-CIWA, Bhubaneswar.
- Mr. Saroj Kumar Singh, Administrative Officer, joined ICAR-IIWM on April, 01, 2017 after transfer from ICAR-IIMR, Hyderabad.
- Dr. Debabrata Sethi, Scientist (Veterinary Extension), joined ICAR-IIWM on July 03, 2017 on transfer from ICAR- CSWRI, Avikanagar.
- Mr. Partha Deb Roy, Scientist (Soil Science), joined ICAR-IIWM on July 10, 2017 on transfer from ICAR-NBSS & LUP-RC, Jorhat, Assam.
- Dr. D.K. Panda promoted to Principal Scientist through CAS of the ICAR w.e.f. October, 24, 2015.
- Dr. R.R. Sethi and Dr. A.K. Nayak promoted to Principal Scientist through CAS of the ICAR w.e.f. September 4, 2016 and December 27, 2016., respectively.
- Mr. Chottelal promoted to Senior Technical Officer through DPC w.e.f. June 29, 2015.
- Mr. R.C. Jena, Mr. P.C. Singh Tiyu, Mr. S.K. Das, Mr. B.K. Acharya and Mr. S. Lenka promoted to Technical Officer through DPC w.e.f. December 19, 2015, December 29, 2015, February 24, 2016, May 21, 2016 and April 18, 2017, respectively.
- Mr. A.K. Binakar and Mr. L. Singh Tiyu promoted to Senior Technical Assistant (Driver) through DPC w.e.f. June 29, 2016.

BUDGET & EXPENDITURE

Budget & Expenditure

2017-18

The Budget & Expenditure for the financial year 2017-18 in respect of ICAR-IIWM, Bhubaneswar

(Figures in lakhs)

Sl. No.	Head of Account	Budget	Expenditure
I	Grants for Creation of Capital Assets (CAPITAL)	75.00	66.44
II	Grants in Aid-Salaries (Revenue)		
	Establishment Charges	762.00	759.62
III	Grants in Aid-General (Revenue)		
1	Pension & Other Retirement Benefits	4.50	4.50
2	Travelling Allowances	15.00	13.86
3	Research & Operational Expenses	104.26	49.82
4	Administrative Expenses	135.00	124.51
5	Miscellaneous Expenses	20.00	14.42
	Total Grant-in-Aid-General	278.76	207.10
	Total Revenue (Grant-in-Aid-Salaries + Grant-in-Aid-General)	1040.76	966.71
	G. TOTAL (Capital + Revenue)	1115.76	1033.16
	AICRP on IWM	2187.00	2185.51
	Agri-CRP on Water	375.00	294.67

Results-Framework Document (RFD)

ICAR-Indian Institute of Water Management

(April 2016- March 2017)

Address : P.O. Rail Vihar, Chandrasekharpur Bhubaneswar – 751 023, Odisha
Website ID : http://www.iiwm.res.in

Section 1: Vision, Mission, Objectives and Functions

Vision

Sustainable development of on-farm water management technologies for enhanced agricultural productivity and improved livelihood under different agro-ecological regions.

Mission

Basic, applied and strategic research activities to address diversified water management issues with institutional linkages, infrastructural support and capacity building to achieve sustainability and growth.

Objectives

- Agricultural water management and conservation measures
- Enhancing water productivity
- Capacity building and human resources development

Functions

- To develop efficient utilization, management and conservation of on-farm water resources for sustainable agricultural production.
- To manage excess water in agricultural lands.
- To develop sustainable cropping systems in relation to the availability of water.
- Devising multiple uses of water in agricultural production programs to enhance water productivity.
- To reuse poor quality groundwater, industrial and municipal waste waters.
- To disseminate technologies through peoples' participation.

Section 2: Inter se Priorities among Key Objectives, Success Indicators and Targets

S. No.	Objectives	Weight	Actions	Success Indicators	Unit	Weight	Target / Criteria Value				
							Excellent	Very good	Good	Fair	Poor
							100%	90%	80%	70%	60%
1	Agricultural water management and conservation measures		Improving irrigation practices	Efficient irrigation technologies to be developed	No.		5	4	3	2	1
			Judicious use of water	Agricultural water use efficient technologies to be developed through network projects and adaptive research	No.		4	3	2	1	-
			Safe use of waste water	Strategies / options for waste water use in agriculture to be developed	No.		2	1	-	-	-
			Water harvesting and groundwater recharge	Technologies for rainwater conservation and groundwater recharge to be developed	No.		4	3	2	1	-
2	Enhancing water productivity		Multiple water uses	Technologies / models for enhancing water productivity to be developed	No.		3	2	1	-	-
3	Capacity building and human resources development		Transfer of technology	Awareness / knowledge up-gradation of farmers, students and other stake-holders	No.		600	550	500	400	350
				Knowledge of the scientists & officials to be updated	No.		7	6	5	4	3

Section 3: Trend Values of the Success Indicators

S. No.	Objectives	Actions	Success Indicators	Unit	Actual values	Actual values	Actual values	Projected values	Projected values
					2014-15	2015-16	2016-17	2017-18	2018-19
1	Agricultural water management and conservation measures	Improving irrigation practices	Efficient irrigation technologies to be developed	No.	2	3	5	4	5
		Judicious use of water	Agricultural water use efficient technologies to be developed through network projects and adaptive research	No.	2	3	4	3	4
		Safe use of waste water	Strategies / options for waste water use in agriculture to be developed	No.	1	1	2	1	2
		Water harvesting & groundwater recharge	Technologies for rainwater conservation and groundwater recharge to be developed	No.	3	3	4	3	4
2	Enhancing water productivity	Multiple uses of water	Technologies / models for enhancing water productivity to be developed	No.	1	2	3	2	3
3	Capacity building and human resources development	Transfer of technology	Awareness / knowledge up-gradation of farmers, students and other stake-holders	No.	15	450	550	500	550
			Knowledge of the scientists & officials to be updated	No.	5	5	7	6	7

Section 4: Description and definition of success indicators and proposed measurement methodology

S. No.	Success Indicator	Description	Definition	Measurement	General Comments
1	Irrigation efficiency technologies to be developed	Pressurized irrigation systems like drip and sprinkler irrigation methods shall be evaluated.	Irrigation efficiency is to characterize irrigation performance, evaluate irrigation water use, and to promote better or improved use of water resources in agriculture.	Irrigation efficiencies will be measured through study of irrigation performance, irrigation water use etc.	Modern irrigation practices and management will yield better irrigation water use efficiency over the farmers' practices in agriculture.
2	Agricultural water use efficient technologies to be developed through network projects and adaptive research	Engineering with bio-engineering propositions shall be developed to enhance water use efficiency	Water use efficiency is defined as yield of plant product per unit of crop water use.	Water use efficiency will be measured through crop performance against total water use through evapo-transpiration.	This will help in enhancing agricultural crop water productivity and profitability.
3	Strategies / options for waste water use in agriculture to be developed	The use of waste water in agriculture shall be addressed to enhance water productivity.	Waste water is the marginally polluted water having potentiality of reusing in agriculture.	Waste water quality parameters will be measured using standard methods following recommended guidelines.	To reduce dependency on surface and groundwater, use of treated waste water in agriculture can be a viable proposition.
4	Technologies for rainwater conservation and groundwater recharge to be developed	Low cost location specific ground water recharge techniques shall be developed.	Groundwater recharge is a hydrologic process where water moves downward from surface water to groundwater.	Groundwater recharge measurement will be studied through development of location specific filter systems.	Groundwater recharge technique shall help in augmenting the groundwater table through minimization of surface runoff.
5	Technologies / models for enhancing water productivity to be developed	Models shall be conceptualized, developed and evaluated for multiple uses of water.	Multiple use of water are low-cost, equitable water use models that provide water for both domestic needs and high-value agricultural production including rearing of livestock.	Under multiple use managements total water use against production of various components will be measured.	This system will help in livelihood improvement, assured production in adverse conditions as well as creation of water resources.
6	Awareness / knowledge up-gradation of farmers, students and other stake-holders	In order to disseminate the various developed on-farm technologies, the training programmes for the farmers and students shall be undertaken.	Transfer of technology through training and demonstration is the process of transferring skills, knowledge, technologies, methods etc to a wider range of users.	Impact assessment of training and demonstration will be measured through systematic questionnaire feedback approach.	Training and demonstration are the effective tools in rapid dissemination of technologies to end user level for enhancing agricultural productivity.
7	Knowledge of the scientists & officials to be updated	Knowledge of the scientists and officials shall be developed on recent advancement techniques through various training programmes.	Human resource development is a framework for the expansion of human capital within an organization through the development of both the organization and the individual to achieve performance improvement	Enhanced knowledge will be measured through aided trainings on new and emerging subjects/tools.	This will update and enhance the existing knowledge level of scientific and other officials of the organization.

Section 5: Specific performance requirements from other departments

Location Type	State	Organization Type	Organization Name	Relevant Success Indicator	What is your requirement from this organization	Justification for this requirement	Please quantify your requirement from this organization	What happens if your requirement is not met
Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Section 6: Outcome / Impact of activities of organization ministry

S. No.	Outcome / Impact of organization	Jointly responsible for influencing this outcome / impact with the following organization (s) / departments / ministry (ies)	Success Indicator	Unit	2014-15	2015-16	2016-17	2017-18	2018-19
1	Enhancing agricultural water productivity through multiple uses and improving livelihood	Departments of agriculture / water resources of state Governments	Enhancement in adoption of pressurized irrigation system	%	16	17	17	17	17

भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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भाकृअनुप - भारतीय जल प्रबंधन संस्थान

ICAR – Indian Institute of Water Management

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